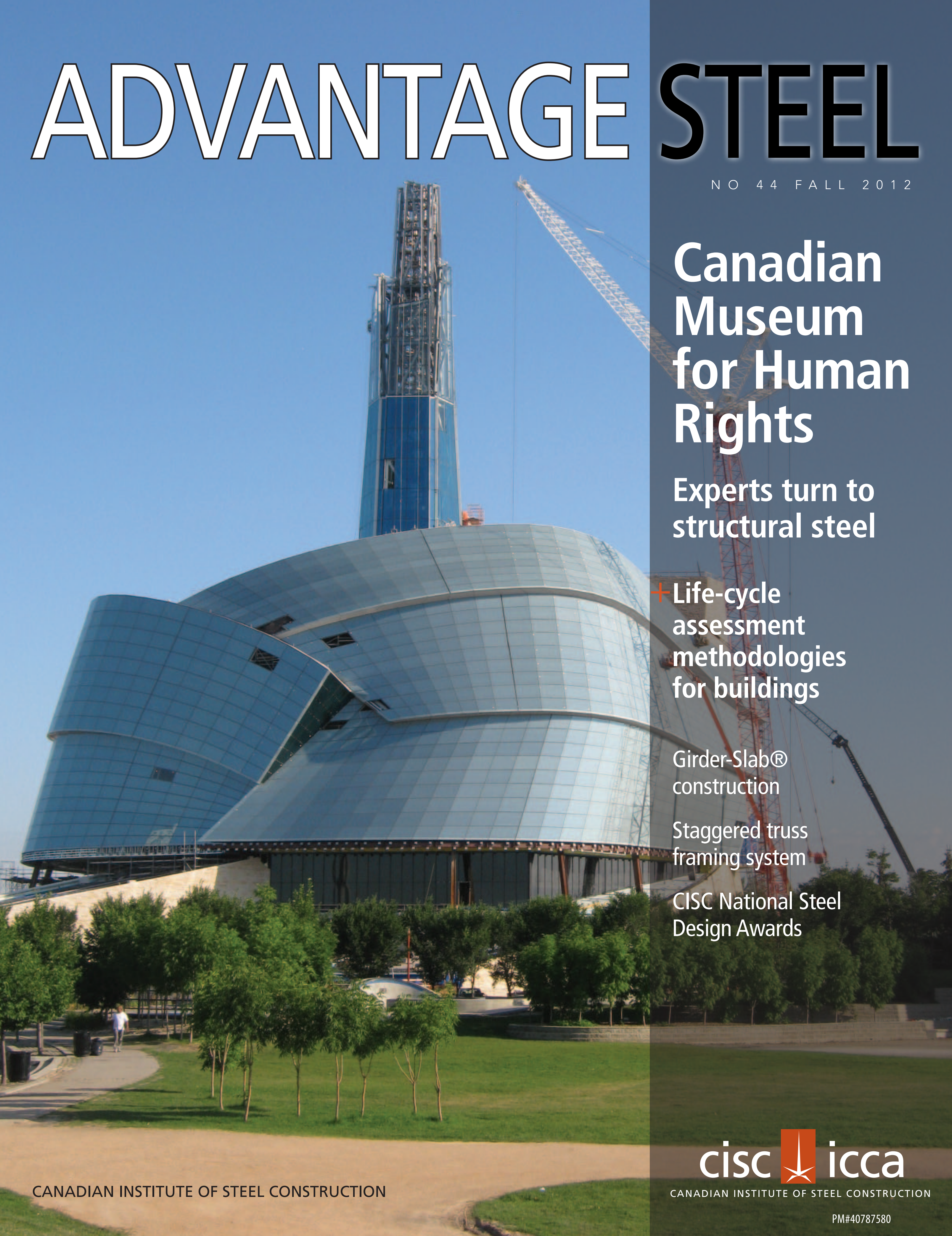

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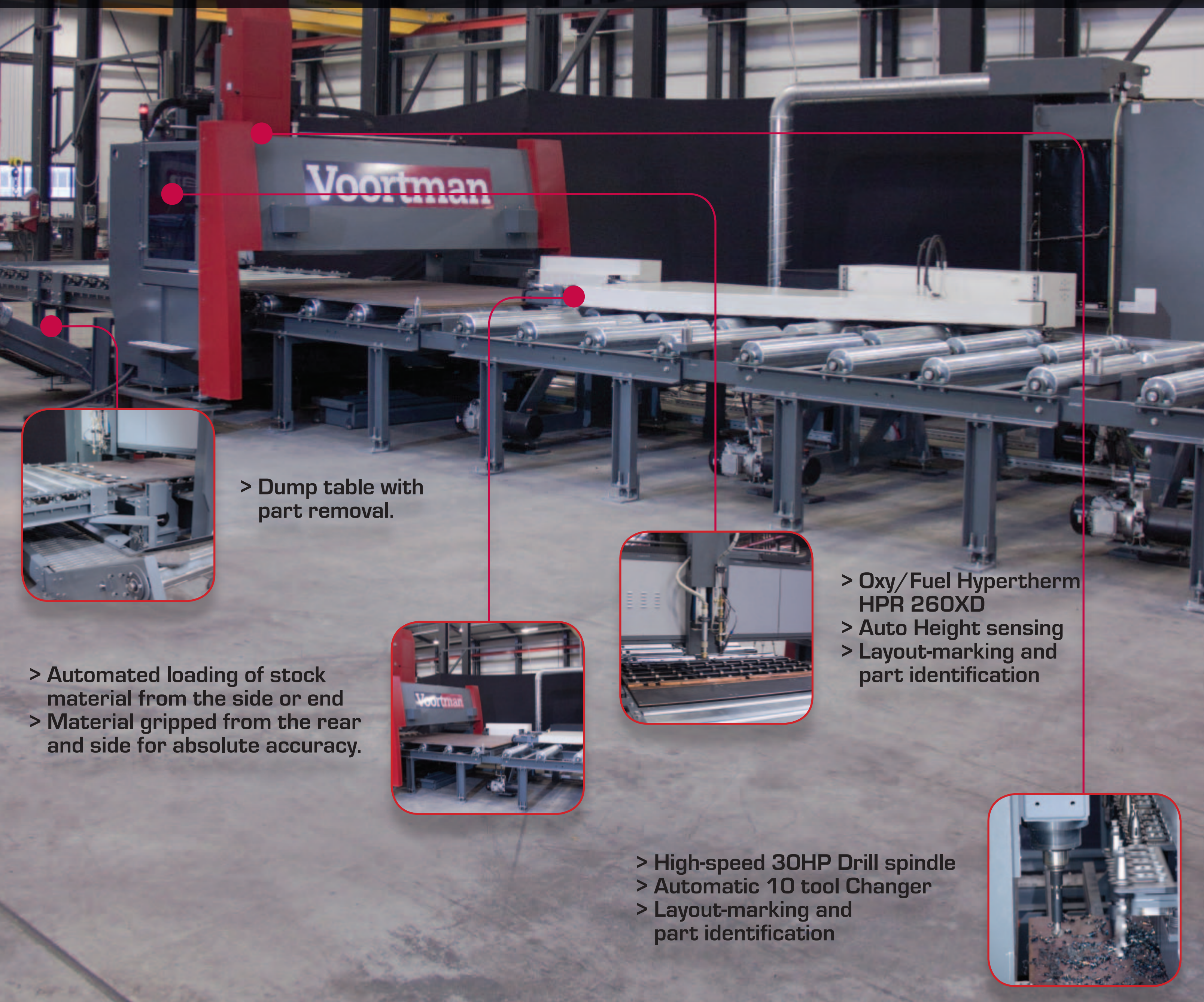

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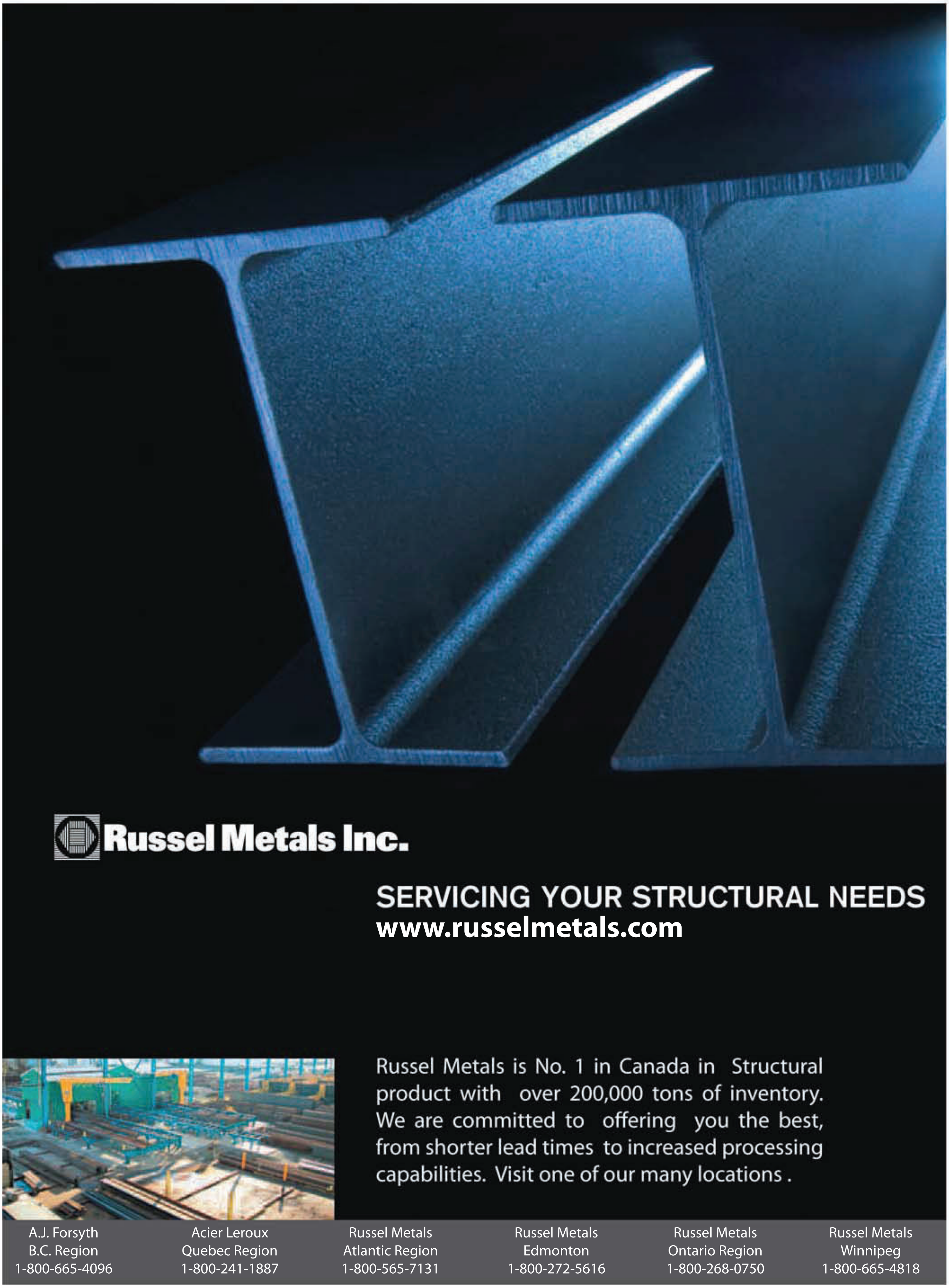
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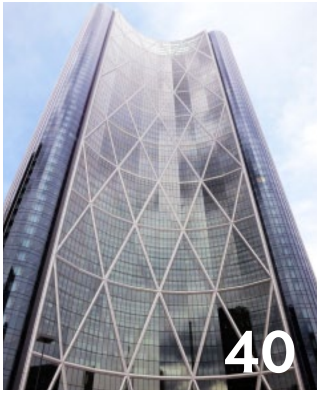

FEATURES

COLUMNS

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By Ed Whalen, P.Eng.

No longer a pipe dream

On its annual SteelDay, on September 28, the Canadian steel industry will showcase its strength and present steel as the premier building material across Canada.

As we prepare for this important event, I can't help but remember a presentation made by Don McDonald of the Australian Steel Institute at CISC's annual conference in Ottawa in June. In approximately two years, the practices of the mining EPCs (Engineering Procurement and Constructors) changed their world forever.

The steel fabricators had done everything right. They invested heavily in technology, they minimized their overhead, and they upgraded the skills of their employees. They were ready and well positioned to reap the rewards of Australia's natural resource boom.

Or, so they thought. Today, their industry is running at 30 per cent capacity or less, at a time when Australia's mining industry is booming.

What did they miss?

Fact one: The act of buying technology alone does not necessarily make you competitive. As they say, you are only as fast as the slowest process. How many of us have truly assessed all of our processes? Do we know how much process improvement we need in order to be locally, provincially, nationally and globally competitive? Australia did not benchmark their production against the rest of the world. Up until that point they were competing locally.

Fact two: There are new methods of constructing. The days of stick-built structures are being replaced with modularization and containerization, allowing for locations of low labour wages in other building trades—such as mechanical and electrical—to affect whether we can get the job. In Australia, most mining projects are located along the coast, making it easy for super-large 10,000-ton modules to be delivered in one piece by ship.

Fact three: EPCs are not holding their suppliers in other parts of the world to the same safety, quality and environmental standards as they do in Canada. Governments in other countries, such as China, have dramatically different safety and environmental standards from what we have in Canada.

So what to do? The first thing is to determine if you truly are competitive locally and nationally. Once that is established you determine your company's competitiveness against the rest of the world.

A doctorate project coming out of Alberta led by Jim Kanerva of Waiward Steel will try to determine just that. In a recent study, Kanerva was able to establish that most companies were looking to set up key performance indicators (KPIs) measuring productivity and competitiveness, but few were able to find the right metrics.

Jim Kanerva's project will establish an Alberta Structural Steel Fabrication and Erection Industry Key Performance Indicator Benchmarking Network. This leading edge research project will:

- Determine, establish and standardize a set of benchmarkable key performance indicators (KPIs);
- Use this set of KPIs to determine, establish and standardize an overall competitiveness factor; and
- Establish a network of industry-sector specific organizations committed to implementing a standardized, third-party audited benchmarking program for determining ongoing competitiveness.

With this information, participating companies will be able to identify and benchmark their position of competitiveness, thus improving their ability to compete.

CISC is hoping to eventually bring this project to a national level. The benefits to our industry are great, especially if we wish to be long-term players in the global world of steel.

ADVANTAGE STEEL

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Professional engineers, architects, structural steel fabricators and others interested in steel construction are invited to inquire about CISC membership. Readers are encouraged to submit their interesting steel construction projects for consideration for inclusion in this publication by contacting CISC.

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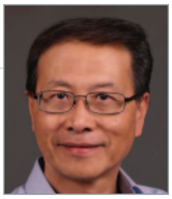


By Alfred F. Wong, P.Eng.

QUESTION 1: When designing fillet welds in shear, is it necessary to check the base metal resistance at the fusion face?

ANSWER: In accordance with S16-01, the shear resistance of fillet welds is taken as the lesser of: (a) the weld metal resistance given as a function of the ultimate strength of the electrode, X_u, and the effective throat area, A_w and (b) the base metal resistance given as a function of its tensile strength, F_u, and the fusion face area, A_m. Unless over-matched electrodes are used, the base metal resistance does not govern the design of longitudinally loaded joints. However, when the weld orientation approaches the transversely loaded case the base metal resistance governs due to the significantly larger weld metal resistance.

In S16-09, it is no longer necessary to check the base metal strength at the fusion face when matching electrodes are used (Clause 13.13.2.2). Research studies conducted at the University of Alberta have demonstrated that the base metal resistance determined using the virgin strength of the base metal does not represent the shear resistance. The researchers pointed to the fact that the properties of the base metal at the fusion face are influenced by intermixing of the weld and base metals. Unless over-matched electrodes are used, base metal resistance at the fusion face need not be checked, regardless of weld orientation.

For a list of matching electrodes for CSA G40.21 steels, see Table 4 in S16-09.

QUESTION 2: When designing bolted connections, are seismic loads considered to be static or cyclic?

ANSWER: The Seismic Corner article entitled "Bolted Connections for Seismic Applications" in the CISC publication *Advantage Steel* No. 31 (Summer 2008) outlined the requirements for bolted connections for seismic applications in accordance with S16-01. The article is available at: www.cisc.ca/publications/advantagesteel/31/Default.aspx.

In NBC 2010 and S16-09, the building height restriction for Conventional Construction where the specified short-period spectral acceleration, $I_E F_a S_a(0.2)$, exceeds 0.35 has been increased. The above-mentioned requirements for bolted connections also apply to these taller structures of Conventional Construction.

QUESTION 3: How do I determine the elastic bending resistance of a cantilever plate subject to lateral-torsional buckling?

ANSWER: For a fix-ended plate subject to bending about its strong axis but laterally unbraced, the *Guide to Stability Design Criteria for Metal Structures*, 6th Edition (R.D. Ziemian, John Wiley & Sons, 2010) gives expressions for the elastic buckling moment (M_u), depending on the height of load application. For example, when subjected to a point load at its tip:

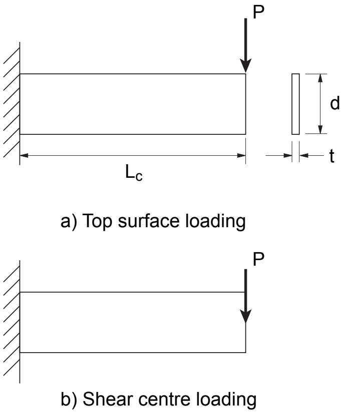
a) For top surface loading:

$$M_u = 1.5\frac{GJ}{d}$$

b) For shear centre loading:

$$M_u = \frac{4}{L_c}\sqrt{EI_y GJ}$$

where E and G are the elastic and shear modulii respectively, I_y is the minor-axis moment of inertia, J the St. Venant torsional constant , "d" the plate depth, and L_c the cantilever length.



CANTILEVER PLATE

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

By Charles Albert, P.Eng.

New provisions for eccentrically braced frames in CSA S16-09

Eccentrically braced frames (EBFs) are used in seismic force-resisting systems to dissipate energy through the yielding of links which form part of the beams in braced bays. Their main advantage consists in combining the structural stiffness of braced frames with the ductility of moment frames.

In an EBF, one or both ends of each brace is connected to a beam so as to form an isolated segment called the "link." Other members of the braced frame are designed for elastic behaviour while the link yields and strain-hardens during seismic motion. Links are classified as "short" if they yield in shear, or as "long" if they yield in flexure.

Design requirements for EBFs first appeared in an appendix to the 1989 edition of CSA Standard S16, taken mostly from the Structural Engineers Association of California (SEAOC 1988). Currently, in S16-09 Clause 27.7, they are referred to as "ductile eccentrically braced frames" and are characterized by a ductility-related force modification factor, R_d = 4.0, and an overstrength-related force modification factor, R_o = 1.5.

This article highlights the principal changes for EBFs in S16-09 with regard to tubular links, columns, column splices and protected zones.

Tubular links

A new feature in S16-09 is the option of using a tubular link consisting of a built-up rectangular box beam (see Figure 1). Unlike the more conventional wide-flange links, tubular links do not require lateral bracing at the link ends. This alternative can offer an attractive solution in areas where lateral bracing is undesirable, for example along an exterior column line, or near elevators and stairwells.

Design and detailing criteria for tubular links include:

- Plastic shear resistance, V_p (Clauses 27.7.2.3 and 27.7.3)
- Complete joint penetration groove welds for connecting the webs to the flanges (27.7.2.4)
- Plate slenderness ratios for the flanges, b/t, and webs, h/w (27.7.2.5)
- Ratio of moment of inertia for out-of-plane bending to that for in-plane bending, eliminating the need for lateral bracing (27.7.2.5)
- Web stiffeners (27.7.6.2.1). Weld attachment of flange stiffeners is not required. Intermediate stiffeners may be welded to the inside faces, enhancing architectural appeal and improving corrosion resistance.
- Increased forces in braces, end connections and columns associated with tubular links (27.7.10.2) are due to their higher strain-hardening response than wide-flange links.

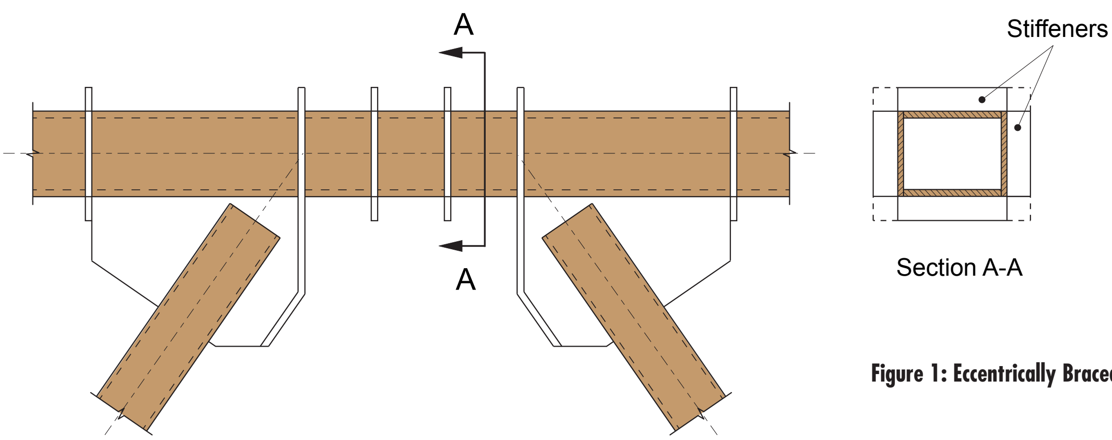


Figure 1: Eccentrically Braced Frame - Tubular Link

Columns

In S16-01, columns in EBFs were designed for combined axial compression and bending with the interaction value limited to 0.65 for the top tier, and 0.85 for all other columns in the braced bay. In S16 09, instead of limiting the interaction value, an additional bending moment of 0.2 Z F_y is applied in the direction of the braced bay together with the computed moments and axial loads. In the top two storeys, the additional moment is 0.4 Z F_y.

Column splices

According to a new design requirement in S16-09, splices in columns must provide the required axial, shear and bending moment resistances including the effects of additional moments of 0.2 Z F_y in the direction of the braced bays, acting either in the same or the opposite directions at the column ends. These criteria ensure column continuity as a means of preventing soft-storey deformations due to yielding of the links.

Protected zones

The concept of "protected zones" was introduced in S16-09, Clause 27.1.9. Protected zones are identified as regions where large plastic strains will occur in the force-resisting system during seismic motion. With some exceptions, attachments giving rise to metallurgical notches or stress concentrations (such as shear studs and decking attachments) are not permitted in protected zones.

For EBFs, the link beam is designated as the protected zone, which extends to one-half the beam depth beyond the ends of the link (see Figure 2). The attachment of welded link stiffeners is permitted in the protected zone.

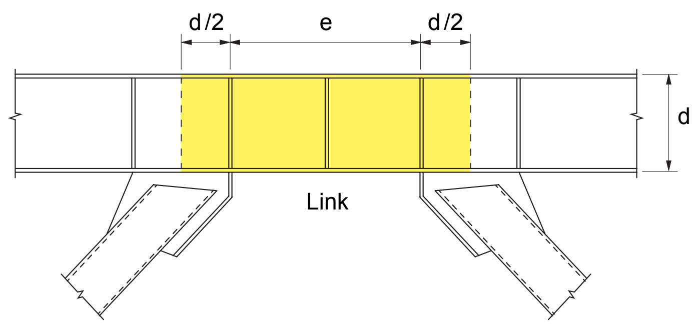


Figure 2: Protected Zone in an Eccentrically Braced Frame

Life cycle assessment methodologies for buildings

By Ivan Pinto, Dr. Mark Gorgolewski, Prof. Vera Straka

Effectiveness of the Athena Environmental Impact Estimator—a leading building LCA tool in North America

Life cycle assessment (LCA) methodology established by the International Organization of Standardization (ISO 14040) evaluates all environmental impacts cumulatively stage by stage over the entire lifespan of a building, product or process. It can provide a more accurate picture of environmental trade-offs and help to avoid shifting environmental burdens between each life-cycle stage. In other words, it is a scientific framework that evaluates the inherent environmental impacts of products, including resource extraction, manufacturing, use and disposal over the full life cycle.

This allows the identification of environmental "hot-spots" amongst life-cycle stages, which may lead to improvement of products. LCA is useful for improving the sustainability of products and processes by identifying "greener" opportunities, and therefore is a tool useful for decision makers. Green building rating tools such as LEED and GreenGlobes are beginning to integrate LCA methodologies into their points systems as a way of demonstrating the "greenness" of the building materials used, and Environmental Product Declarations (EPDs) using LCA to assess construction product characteristics are increasingly required in some parts of the world.

The Athena Environmental Impact Estimator (EIE) is the leading building LCA tool in North America, designed to facilitate the assessment of environmental impacts of industrial, institutional, office and residential buildings. The software simulates over 1,000 different assembly combinations for building envelope and structural systems and it claims applicability to about 95 per cent of the building stock in North America. It predicts cradle-to-grave environmental impact data for building designs using categories defined by the U.S. Environmental Protection Agency (EPA), which include: primary energy consumption, global warming potential, weighted resource use, acidification potential, human health respiratory effects, eutrophication potential, smog potential and ozone depletion.

A project at the Department of Architectural Science at Ryerson University investigated the accuracy of alternative modelling options available in the Athena EIE model to calculate the impact of steel- and concrete-framed buildings.

There are two approaches to modelling of a building using Athena EIE. First, the conventional Athena EIE input method uses standard assembly dialogue boxes to select construction assemblies from a predetermined menu (Model 2 – EIE by assemblies). This user-friendly method has a series of predefined assembly groups: foundations, walls (exterior and interior), roofs, columns and beams, and floors. The user can select envelope characteristics for each assembly group in order to better represent the whole building

Table 1 – Comparison of the embodied impacts for the steel and concrete buildings using different LCA tools

STEEL BUILDING - EMBODIED Whole building models	1. ECO-CALCULATOR	2. Athena EIE using default assemblies	3. Athena EIE using material quantities	
PEC - Primary Energy Consumption (GJ)	20,444*	24,243	22,050	
GWP - Global Warming Potential (tonnes CO_2 eq)	1,556	1,306	1,283	
CONCRETE - EMBODIED Whole building models				
Primary Energy Consumption – PEC (GJ)	26,064*	22,187	21,818	
Global Warming Potential – GWP (tonnes CO_2 eq)	2,438	1,720	1,697	
Note: Eco-Calculator software does not provide Primary Energy Consumption result; instead it shows Fossil Fuel Consumption.				

design. Once the user has developed the model of a building or its parts, the software can provide a bill of materials which is used to calculate environmental impacts.

To test the accuracy of the Athena-calculated bill of material quantities used in typical steel-framed and concrete-framed office buildings, a second analysis was carried out. This second method required the manual quantity take-off of materials and inputting them by units of weight or volume (Model 3 – EIE by quantities). The software then calculates the environmental impacts. This method allows more flexibility and is considered to be more accurate because the material quantities can be more accurately tailored to a specific project.

For further comparison, the buildings were also analyzed using Athena Eco-Calculator (EC), which is a free, online, spreadsheet tool that allows simplified LCA comparisons (Model 1 - EC).

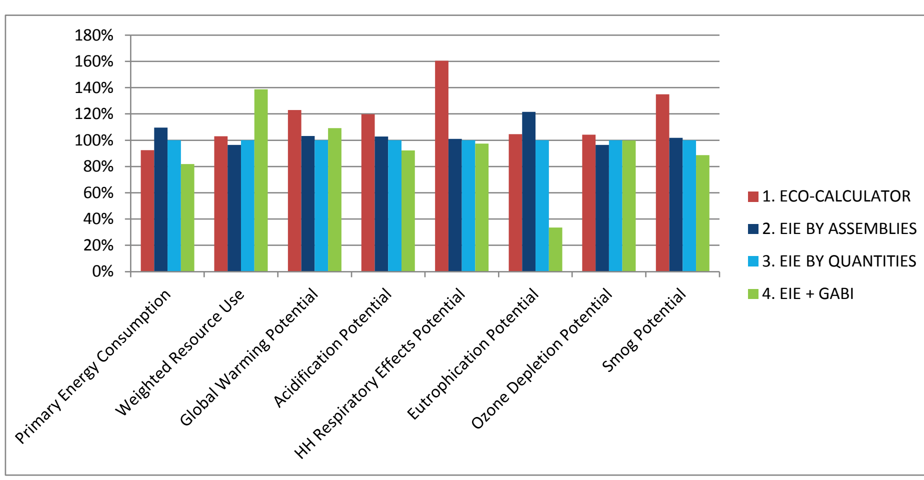
Building type assessed

LCA analysis requires that a consistent "functional unit " is used for comparison, and for this study this was defined as a six-storey, 94,000-sq-ft (8,740m²) office building located in Toronto. The Canadian Institute of Steel Construction (CISC) provided details of a typical office building with a steel structure. The Department of Architectural Science at Ryerson University designed an equivalent building using concrete. In order to ensure a consistent functional unit, both the steel- and concrete-framed buildings have the same characteristics and the structural system is the only design variation.

Modelling methodology comparisons

Table 1 shows results of different modelling options for the steel- and concrete-framed buildings. This comparison shows a significant difference in the results between the four modelling methods. Particularly surprising is that the Athena EIE models using dialogue boxes (Model 2) and Athena EIE using material quantities (Model 3) show significant variation, particularly for the steel-framed design. This is likely due to the assumptions Athena EIE software adopts for steel systems. Figure 1 shows a comparative graphic analysis of the various impact categories.

Figure 1 - Steel building models embodied impact (structure only) results (relative to EIE by quantities)



Further investigation suggests that Athena EIE assembly dialogs over-estimate materials for columns and beams. A comparison of the bill of materials generated by the Athena EIE (Model 2 – by assemblies) with hand-calculated material quantities and volumes (Model 3 – by quantities) found that the Athena EIE predetermined assemblies under-estimate the mass of steel decking and rebar, but significantly overestimate the amount of steel required for wide flange (WF) sections. Compared to the manual calculations the predefined assemblies included nearly double the amount of steel for WF sections. Since WF sections are approximately 57 per cent of the total weight of steel in the building, this difference means that the EIE software overestimated the steel weight by approximately 28 per cent, which has a significant impact on the overall LCA results. Furthermore, the software seems to automatically assume OWSJ supporting steel deck floor system at spacing of 48″ (1200 mm) o/c, and does not allow for modification.

For the concrete building a similar comparison for above-grade structural materials suggested that the Athena EIE predefined dialog method significantly overestimated the volume of concrete and rebar weight for columns. However, columns are a small proportion of the total concrete used in a concrete structure and therefore when considering the total material quantities in the building, the results indicate reasonable agreement (an average variation of six per cent) for the two alternatives of data input methods. Furthermore, the results using the simplified, web-based EcoCalculator tool vary significantly for the concrete frame design.

Conclusions

The research highlights the difficulty of carrying out accurate LCA for complex building projects, and in particular of using simplified, standardized systems to predict the structure of complex buildings. The Athena EIE tool is respected as a useful design tool to help with understanding the life-cycle environmental burdens of design decisions. The software has a significant applicability for the construction industry as a design tool and this article presented one of many. However, this project highlights that using the standardized dialogue boxes to input structural information leads to some error, and so for accurate assessment alternative methods are recommended (especially important for structural systems with uneven bays).

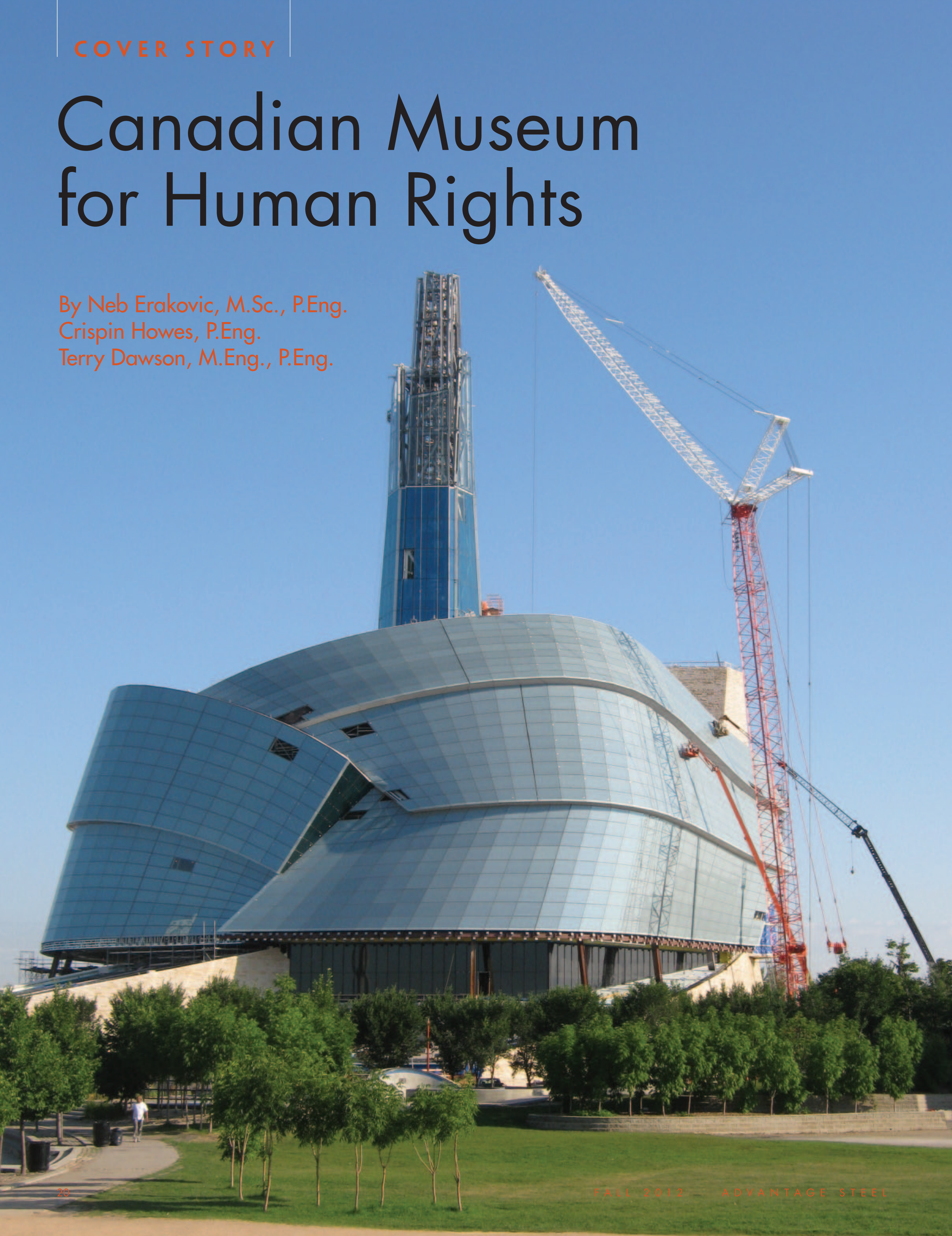
It also suggests that without careful consideration it is dangerous to compare results of LCA analyses using different tools or methodologies. These tools are perhaps more powerful as aids to design improvement of a particular building, rather than as a way of comparing a variety of buildings.

This study was carried out by Ivan Pinto, MASc candidate, and supervised by Dr. Mark Gorgolewski and Prof. Vera Straka at the Department of Architectural Science, Ryerson University, in collaboration with the Canadian Institute of Steel Construction (CISC), and funded by the Steel Structures Education Foundation (SSEF) and MITACS Accelerate. The authors are grateful for the assistance provided by Mr. David MacKinnon from CISC and Ms. Clare Broadbent from the World Steel Association (WSA).

To access the full report, please visit www.arch.ryerson.ca/?page_id=366.

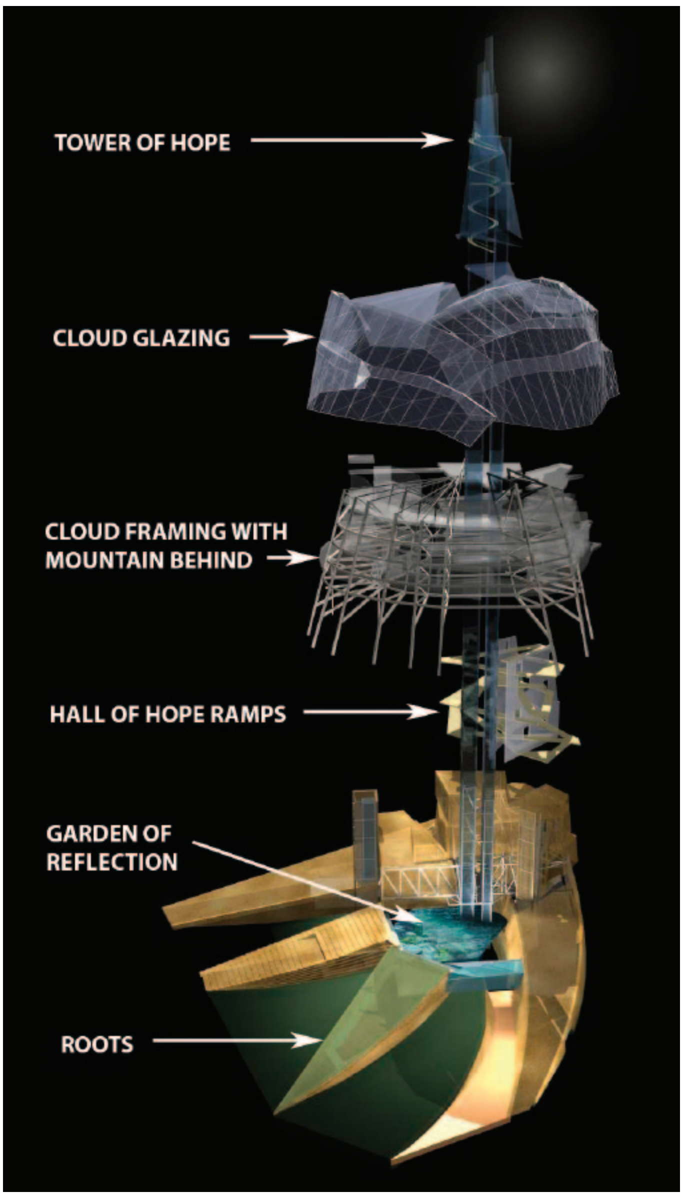
Canadian Museum for Human Rights

By Neb Erakovic, M.Sc., P.Eng.
Crispin Howes, P.Eng.
Terry Dawson, M.Eng., P.Eng.



Experts turn to structural steel to overcome challenges in constructing Canada's newest—and possibly most ambitious—national museum

Figure 1: Exploded view of museum components (Courtesy: Antoine Predock Architect)



Located in the geographical centre of the continent at The Forks of the historic Red and Assiniboine rivers in Winnipeg, Manitoba, the architectural design for the Canadian Museum for Human Rights (CMHR) was selected from an international competition that included 62 submissions from 21 countries.

Antoine Predock's winning design draws inspiration from the natural scenery and open spaces of Canada. Initiated in 2003 by CanWest founder Israel (Izzy) Asper to be the largest human rights institution and education centre in the world, the CMHR is currently under construction and is made possible by a partnership that includes the Government of Canada.

Yolles, A CH2M HILL Company, (Yolles) was selected to provide structural engineering consulting services for the building. Yolles completed this challenging task by collaborating with the architects to translate their vision. It is one that turns organic forms into rational structural component solutions, tied together to create a unique building structure that is both stable and constructible.

As illustrated in Figure 1, the CMHR is generally composed of four base "Roots" radiating out from a central Great Hall and Garden of Reflection beneath a suspended Mountain, Cloud and Tower of Hope. The 50m-tall Hall of Hope atrium at the back of the building cuts into the Mountain and Roots like a canyon and houses circulation ramps. The Roots contain the functional spaces of the museum and are constructed of sloping, segmented, reinforced concrete walls. The Mountain contains the bulk of the exhibition spaces and the Cloud encapsulates office spaces and a large atrium. Projecting above the Cloud roof, the Tower of Hope houses an observation gallery to provide visitors with a stunning view of The Forks, downtown Winnipeg and the surrounding prairie.

Generally, the building superstructure is constructed of structural steel to frame the complex geometry, including the sloping walls of the Mountain exhibition galleries, the curved Cloud façade, the Tower of Hope spire, the Garden of Reflection and the Hall of Hope ramps. In this article, we look at how structural steel is applied to overcome design and construction challenges for many structural components of the building.

Mountain

The Mountain consists of a seemingly randomly stacked array of five stone-clad closed forms of irregular shape shown in Figure 2 suspended 18 metres above ground-floor level. Initially conceived in reinforced concrete, design challenges including highly stressed contact points between forms, long column-free spans, significant form cantilevers, large circulation openings in form walls, sloping form walls, eccentricity of stone cladding, and unconventional vertical and horizontal load paths necessitated a change to structural steel framing.

Structural steel W-sections combine with corner circular hollow sections to form primary diagrid wall trusses within each two-storey form wall. Significant floor openings added complexity to the buckling restraint of diagrid wall truss compression members, requiring heavy W360 column sections in some locations. Composite steel beams and slabs frame the Mountain floors by clear spanning between the diagrid wall trusses. Steel bracing beams and cover plates are added where diaphragm floor forces overstress concrete slabs.

Diagrid wall trusses span significant unsupported distances between concrete wall and steel column supports. The locations and angles of the diagonal and vertical elements within the diagrid wall trusses are positioned around wall openings to provide direct load paths down to supports. The diagonals also transfer lateral loads down the building with floor diaphragms distributing those loads across to supporting walls.

Parametric sensitivity analyses were conducted to assess the effects of changes in temperature, concrete slab and wall cracking, construction sequencing and staging, and connection fixities. Optimizing the diagrid wall truss member locations, designs and connections with consideration to these parameters is complicated by the redistributive nature of the stacked diagrids. However, alternate load path benefits are ultimately realized with the implementation of a lower bound philosophy to the member and connection designs.

Steel connections are designed by Walters Inc. with utilization of their four-dimensional design and modelling capabilities to rationalize the Mountain connection nodes.

Project Team

OWNER: Canadian Museum for Human Rights

DESIGN ARCHITECT:
Antoine Predock Architect PC (Albuquerque, NM)

EXECUTIVE ARCHITECT: Smith Carter (Winnipeg, MB)

CONSTRUCTION MANAGER:
PCL Constructors Canada Inc. (Winnipeg, MB)

STRUCTURAL ENGINEER OF RECORD:
Yolles, A CH2M HILL Company (Toronto, ON)

LOCAL STRUCTURAL ENGINEER:
Crosier Kilgour & Partners Ltd. (Winnipeg, MB)

CISC STRUCTURAL STEEL FABRICATOR:
Walters Inc. (Hamilton, ON)

GLAZING SUPPLIER: Josef Gartner GmbH (Germany)

MECHANICAL & PLUMBING ENGINEER:
The Mitchell Partnership Inc. (Toronto, ON)

ELECTRICAL ENGINEER:
Mulvey+Banani International Inc. (Toronto, ON)

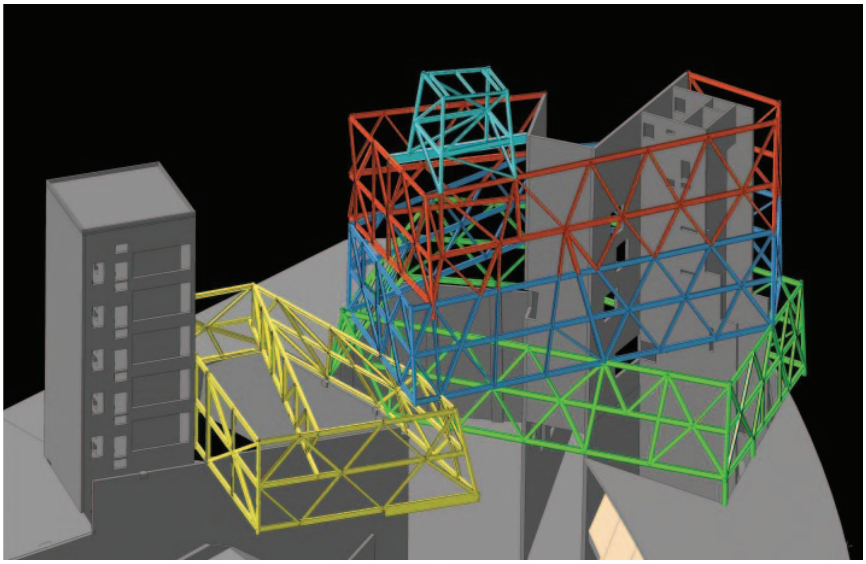
At one of the "super-nodes," colloquially dubbed the "turkey tail," 10 members join where two sloping wall trusses meet over a supporting wall. The complexity of the super nodes is illustrated in the modelling and fabrication examples shown in Figure 3.

The lower Mountain form cantilevers 16 metres over part of the Garden of Reflection. A disproportionately small 20-metre back span requires the floor diaphragms at the top and bottom levels of this form to act as a horizontal force couple to provide supplemental resistance to overturning of the cantilever. The massive supported weight of stone cladding, heavily loaded exhibition and plant floors, upper Mountain, Cloud roof and the Tower of Hope require this form to be super elevated at erection to ensure flat floors in the final condition. Extreme loads also require six 500mm x 100mm solid steel plates to be built up to form a solid 500x600 steel diagrid member. Four freestanding, 18-metre-tall "mega shore" towers temporarily shored the form during erection of the frame until the concrete slabs of the floor diaphragms were poured and cured. The design and construction of this cantilever form proved to be the most challenging aspect of the project, and the successful release of the mega shores was a celebrated project milestone.

Cloud and Tower of Hope

The glazed Cloud encapsulates the large central atrium shown in Figure 4, allowing natural light to flood the museum offices and the Garden of Reflection. A primary

Figure 2: Diagrid wall trusses of stacked mountain forms



Antoine Predock's winning design draws inspiration from the natural scenery and open spaces of Canada structural framing geometry incorporates the curvature of the Cloud including the folding Cloud "Dove Wings" shown in Figure 5. Raking built-up hollow steel columns span over 30 metres from the Roots up to the Cloud roof and support a series of 610mm-diameter hollow circular steel pipes curving around the Cloud perimeter at varying radii. Balcony-like partial perimeter office floors encircle the atrium at three levels and act as diaphragms to provide lateral stability to the raking columns.

Steel framing also allows light into the Tower of Hope and practically unobscured panoramic views out. The underlying geometry consists of two overlapping cones discretized into faceted shards of layered glazed panels.

Other structural building features

Envisioned as Winnipeg's Winter Garden, the Garden of Reflection is located at the base of the Cloud atrium. After descending the elevator from the Tower of Hope, still water reflective pools and Basalt stone seating offer an opportunity for contemplation. A two-directional, long spanning, steel truss support system provides column-free space for the dark void of the Great Hall below and supports the Tower of Hope elevator hoist-way and spiral stair above. In its central location, the Garden of Reflection is adjacent to all four Roots, three building cores and the Hall of Hope, and floats between these structural components on sliding bearings to prevent the attraction of significant compatibility forces.

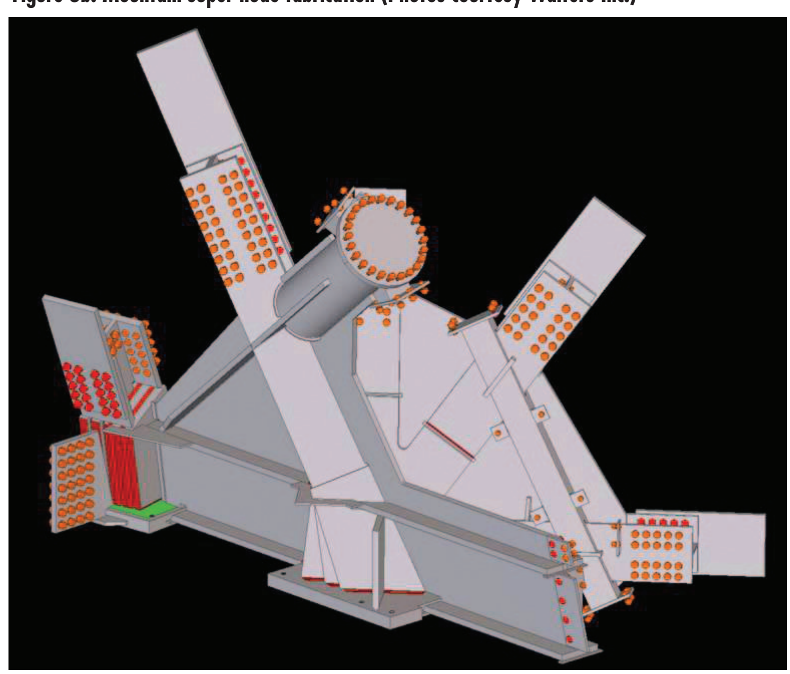
Up to 25-metre long-span steel pony trusses are located within the glowing backlit alabaster stone-clad balustrades of the circulation ramps that link the museum exhibition spaces and fly through the Hall of Hope atrium. Each ramp is unique in span and supports; however, a repetitive structural framing system rationalizes the fabrication and construction as shown in Figure 6.

The complex interfaces between the structural steel superstructure and supporting concrete walls required careful design and construction coordination. Hundreds of cast-in-plates, numerous bearings and corbels, and thousands of reinforcing steel form savers, couplers and terminators are utilized to tie the structural components of the building together. Concrete elements were surveyed for location and orientation for incorporation into steel fabrication where permitted by schedule to mitigate potential erection problems.

Four freestanding, 18-metre-tall "mega shore" towers temporarily shored the form during erection of the frame until the concrete slabs of the floor diaphragms were poured and cured

Figure 3a: Mountain super node

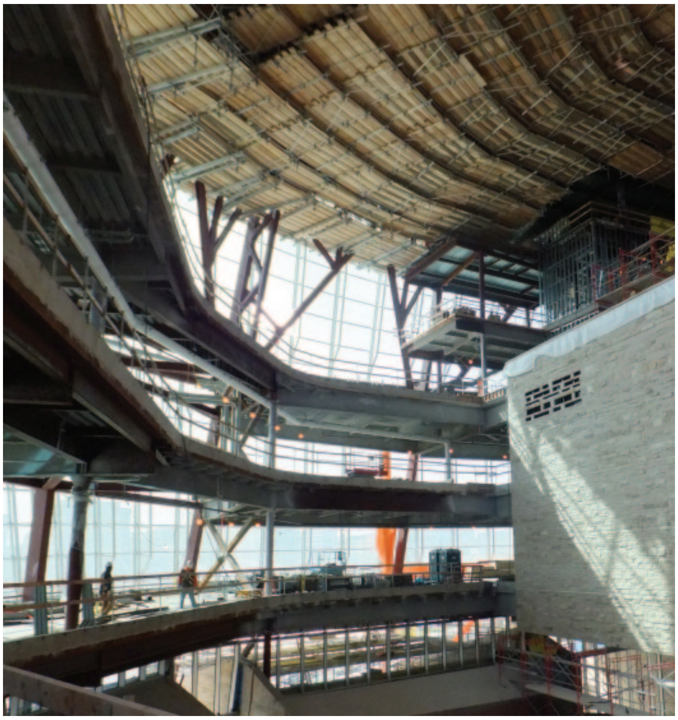
Figure 3b: Mountain super node fabrication (Photos courtesy Walters Inc.)



Structures exposed to extreme temperatures require the designer to consider the method and schedule of construction. Owing to the prairie climate, it was anticipated that the structure could experience temperature differentials of at least 30˚ C prior to enclosing the building. Locking the various steel components of the structure into the supporting concrete walls would result in unacceptably high thermal restraint forces and potential damage. No expansion joints are possible for the building because of the need for continuous diaphragms to resist wind loads and hold sloping, cantilevered, unbalanced parts of the building together. For mitigation, temporary steel slip connections and slab separation strips are used to disconnect selected structural components during construction with temporary bracing introduced to maintain stability until the building was enclosed.

Classical "by hand" methods of structural load path visualization and analysis for temporary and permanent conditions are impractical for a building with this degree of complexity. Finite Element Method (FEM) analysis is more suitable; however, its use is contingent on being able to accurately represent the three-dimensional geometry of the building.

Figure 4: Cloud Atrium between offices and Mountain and over Garden of Reflection



By now, the advantages and disadvantages of Building Information Modelling (BIM) are well documented in the building construction industry. However, at the time of CMHR design initiation it was a relatively new technology that forced a cultural change to the design consultant teams. For the complex three-dimensionally curved and sloping geometric forms of this building, Yolles developed a sophisticated workflow to capitalize on the best aspects of several software programs more common to the industrial, automotive and aircraft industries. Various components of the building, such as the Mountain, Cloud and Tower of Hope, were broken out and individually translated from design concept into structural components that were manipulated back into the master BIM geometric model. Ultimately, the benefits of BIM were realized in excellent 3D visualization, sharing of information for coordination, and clear contract documentation. BIM was clearly the best tool to manage the structural complexity of this building.

In summary, structural steel is used to overcome numerous design and construction challenges for the architecturally complex CMHR superstructure.

Figure 5: Cloud Dove Wings and Tower of Hope

Building statistics

- Construction start 2009, completion 2013
- $350 million approximate construction cost
- 50-metre height to top of Cloud Roof
- 100-metre height to top of Tower of Hope
- 12 storeys with average 5.2-metre floor-to-floor height
- 24,154 square metres total floor space
- 4,350 square metres of exhibition space
- 4800+ metric tonnes of structural steel
- 770 metres total length of ramps
- LEED Certified Silver (expected upon completion)

These challenges include the stacked forms of the Mountain, the rationalized geometry of the Cloud and Tower of Hope, the Garden of Reflection and the long-span Hall of Hope ramps. BIM was successfully used to model and document the building structure, with various software used to analyze and design advanced, rational, geometric solutions for each structural component.

Museum visitors sitting and gazing into the still waters of the Garden of Reflection to contemplate the issue of human rights will see the reflection of a stunning building above them, which in turn reflects the innovative design and construction employed to realize the architectural vision of Antoine Predock. Steel was the only feasible material of choice to satisfy the challenges posed by this architectural vision, and the resulting magnificent building will be a true testament to the importance that Canada, as a nation, places on human rights.

Figure 7: CMHR construction progress (Courtesy: Antoine Predock Architect)

Figure 6: Hall of Hope ramps prior to installation of stone cladding

Neb Erakovic, M.Sc., P.Eng., is a Principal in Yolles' Toronto office. He specializes in structures with architectural complexity and can be reached at neb.erakovic@ch2m.com.

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Terry Dawson, M.Eng., P.Eng., is an Associate in Yolles' Toronto office. He has over 10 years' experience in structural engineering in Canada, the U.K., U.S. and New Zealand and can be reached at terry.dawson@ch2m.com.


NUCOR-YAMATO
STEEL

A first for Canada

Supreme Group awarded Canada's first Girder-Slab® method of construction for its work on Edmonton's Courtyard Marriott Hotel

By Peter Timler, M.Sc., P.Eng.

Figure 1: East wing of hotel under construction by ironworkers

Figure 2: Construction progress in early June 2012

For Supreme Group, an opportunity to be involved in a third consecutive project for the ongoing expansions at the Edmonton International Airport was reason enough to propose innovative ideas with the owner and design team assembled for the planned 178,000 sq. ft. Courtyard Marriott Hotel. Those early meetings were focused on understanding the needs of the project and sharing knowledge of a newer method of steel-framed construction to satisfy the imposed requirements of minimizing cost and construction duration within a cold-climate environment.

It's no secret that relatively limited construction projects utilize steel framing for the structure of residential developments in Canada, and in a grander sense, North America. However, that trend is definitely changing, and for good reason. To meet an aggressive opening season soon after the planned completion of expansion works at the airport, Supreme Group introduced the concept of a successful composite-steel-framed and hollow-core plank flooring system known as the Girder-Slab® method of construction.

Originally conceived, tested and further developed in the United States over a decade ago for broad application to the residential market (hotels, dormitories, apartments, condominiums and senior care facilities), it has been applied to approximately 90 construction projects spanning several countries and encompasses some 6,200,000 sq. ft. of finished floor area. Hence, ample evidence of numerous benefits over conventional methods of multi-storey residential construction has been well demonstrated.

The core of the innovative structural system that could be competitive to cast-in-place concrete construction is recognized as the D-Beam®, a simply modified structural wide-flange shape that supports long-span 8" hollow-core panels on its bottom flange. The shape is produced by cutting a saw-toothed pattern on the web area of a select range of wide flange shapes to produce two equal, yet opposite hand, T-Sections and generates no waste. By centring and welding a narrow flat bar of greater thickness than the bottom flange, a dissymmetric section is produced with a regular pattern of penetrations through the web.

This family of specialized floor framing elements, together with the assembly of supported hollow-core panels grouted monolithically with the special purpose beams, are the patented methods for floor construction by Girder-Slab Technologies LLC of New Jersey. By pulling nearly all the structural depth of the steel framing system into the thickness of the floor plate, a minimal floor-to-floor height condition is achieved, essentially matching the cast-in-place method that had previously been a near monopoly in such a construction market.

By introducing a low floor-to-floor height solution to the owner and design team for the six-level tower section above the main two-storey podium, with promise for a shorter erection period (coupled with strong potential that heating and hoarding costs could be either eliminated or reduced dramatically due to the near "dry" construction method), well-founded arguments had been made to change from the original plans for a full concrete structure. In fact, the owner shared that an additional level of hospitality space could be incorporated due to budget allowance and minimal structural height requirement. Further to that, for additional benefit of single-site trade dependence and reduced temporary works, Supreme Group developed a preliminary structural design for consideration that proposed elevator and stair shaft cores as braced-frame lateral load resisting elements for the structure, including steel stair inclusion for immediate construction access in the primary steel contract.

Courtyard Marriott Hotel

PROJECT OWNER: Diamond Airport Hotels Ltd. (Platinum Investments)

CONSTRUCTION MANAGER: Goldsmith Consulting Design Associates

HOSPITALITY DESIGN CONSULTANT: Goldsmith Consulting Design Associates

ARCHITECT: E.F. Gooch

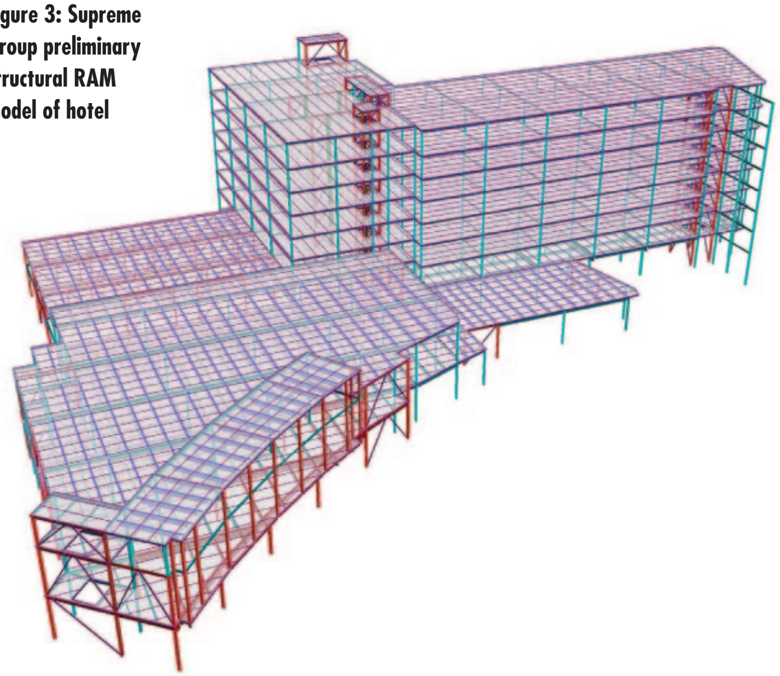
STRUCTURAL ENGINEER: Williams Engineering Canada

STEEL FABRICATOR/ERECTOR: Supreme Steel LP

STEEL DETAILER: CadMax

HOLLOW-CORE SUPPLIER/ERECTOR: Armtec

Figure 3: Supreme Group preliminary structural RAM model of hotel



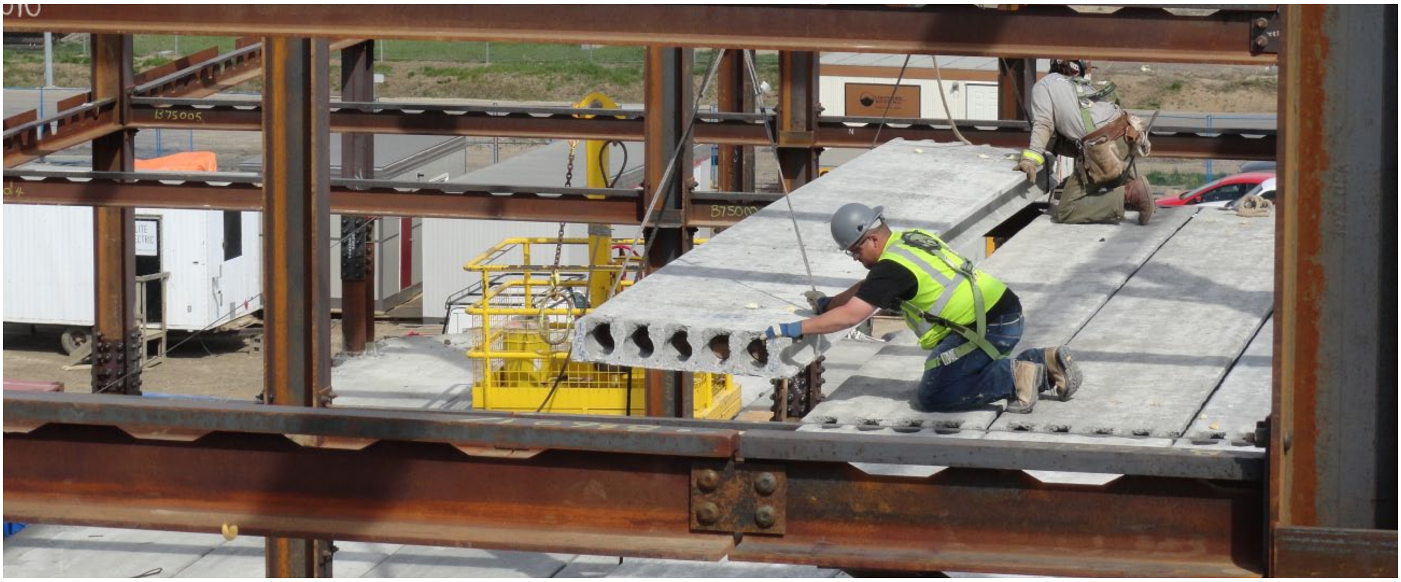


Figure 4: Hollow-core panel installation

Design refinement

With enough information gleaned from Supreme Group's early involvement work reflecting better value propositions, the next step was to work through design refinement with the established team. To meet a fall 2011 steel framing construction start, Supreme Group proposed an Integrated Project Delivery method and set out the program that would meld the efforts of its engineering and project management expertise with the architectural, hospitality specialists and structural consultants already engaged.

Apart from model file sharing and conditions of continuous open dialogue, an atmosphere of trust and collaboration for the benefit of the project was quickly realized. Within a few short weeks, confirmation of the proposed all-steel design, and late architectural changes made to satisfy new requirements for the Marriott Hotel chain, were managed and steel was ordered. This process alone shortened the conventional design period for development of construction drawings by several months.

The Girder-Slab® system has recognition through UL and ULC listings in the U.S. and Canada, respectively, and Girder-Slab Technologies LLC has referenced this information in their design guide, which is available on their website. For the pre-cast industry in Canada, the long-established process to satisfy jurisdictional building officials for two-hour fire rating of hollow-core floor systems has been by submission of calculations under a Professional Engineer's Seal following the Precast/Prestressed Concrete Institute's method of derivation that is acceptable by the National Building Code of Canada.

Hence, for those that recognize ULC's reference to a select number of U.S. precast suppliers in their listing due to limited historical test data, the alternate submission route is a viable method. The exposed steel flange of the D-Beam® is fire protected by conventional means, i.e., sprayed-on cementitious fireproofing or through standard gypsum wall board application.

For the Edmonton International Airport Courtyard Marriott Hotel, a decision was set on application of a nominal ¾" leveling compound as the topping for the hollow-core planking. The Girder-Slab® system has the capability of accepting 2" topping as well. Alternatively, in many lower cost applications in the U.S., dormitories in particular, floor finishes are applied to "carpet ready" hollow-core planking without any topping. The Structural Engineer of Record is typically involved in this decision-making process, as some consideration may be required respecting performance of diaphragm horizontal load transfer in seismic regions. For this project's application, however, seismic design is not a governing factor in the Edmonton region.

The Girder-Slab® method of construction is predicated on delivery of a completed structural system by a qualified steel fabricator that has previously achieved recognition within Girder-Slab Technologies LLC's licensed distributor network. Although various elements and the system have been patented in many countries, the application is non-proprietary and hence invites open-market suppliers in the steel and pre-cast industries to vie for projects designed for tendering. Therefore, it is to be understood that for the right to build with this method, the steel fabricator is engaged in the full structural frame and hollow-core supply and erect, reinforcing steel supply and install (composite D-Beam® joints) and grouting supply and placement.

Topping and fire protection application could also be considered as part of the scope, however they are optional in delivery of a completed structural system. By encompassing the full structural system scope, effective control is maintained in planning the erection of the structure from an efficiency perspective. At the conclusion of the project, the steel fabricator is obligated to issue a compliance certificate to the owner identifying that the structure was built in accordance with Girder-Slab Technologies LLC's specific requirements.

Supreme Group and the design team were also faced with the challenge of incorporating an exterior precast wall panel system that had been non-typical for earlier Girder-Slab® structures in the U.S. A dressed-up D-Beam® for spandrel applications became the most cost-effective means to support the heavy cladding system.

Solid execution

With top-out of the structural system scheduled for early summer of 2012, Supreme Group and its supply team are very pleased with the project's execution given this first application experience. In fact, all others associated with the decision process on the structural scheme—owner, architect, hospitality design consultant, structural engineer of record and construction manager—have expressed very complimentary statements regarding the cleanliness, efficiency and proficiency on the installation of the system.

This doesn't happen through an osmosis process. Very careful planning —a forte for Supreme Group—to cover many aspects of the design for safe and reliable erection was continuous behind the scenes. Examples of the areas where consideration was required included camber control on D-Beams®, camber differential control with hollow-core, stabilization of structure during erection with weld plates, pre-cast plank end preparations, weep requirements, sequence planning for steel and hollow-core placement with single trade (ironworker) crews, grouting operations, temporary framing works, exterior panel connections, mechanical penetrations layout planning, grout damming details and transport logistics, to name a few. It is estimated that this construction method shaved approximately six months off the build-out schedule for a project of similar size had conventional means been deployed.

In summary, what was promised is being delivered: a sound structural system meeting the requirements of a high-end hospitality industry provider ahead of schedule and below cost compared to previous conventional means. We use the word "previous" as a literary gauntlet to the perception that the cast-in-place method of construction will continue as the preferred structural system for such projects. Since securing the Edmonton International Airport Courtyard Marriott Hotel, many developers have expressed interest and attended site visits to view firsthand the general simplicity of the construction method. They are either developing their own projects with the Girder-Slab® system or are serious about its consideration.

Having examined many projects for potential incorporation of the Girder-Slab® method of construction, Supreme Group has developed a considerable knowledge base on efficient application objectives and welcomes inquiries to assist in best value determination of projects. Please contact peter.timler@supremegroup.com for further information.

Peter Timler, M.Sc., P.Eng., is Corporate Business Development Officer and Vice President Engineering at Supreme Group LP.

Design revitalized

Staggered Truss framing system used in the Toronto Christian Resource Centre's new headquarters

By Fernando Cruz, M.Eng., P.Eng. & Michael Jelicic, P.Eng.

40 Oak Street under construction

The Toronto Christian Resource Centre's (CRC) new building at 40 Oak Street in downtown Toronto is a multipurpose facility designed to help the agency fulfil its objective to provide people with life's basic necessities, including affordable housing. It is located in the heart of Regent Park, Canada's largest and oldest social housing community. Funded by the CRC, Toronto Community Housing and government partners at the city, provincial, and national levels, the building is part of the City of Toronto's plan to redevelop and revitalize the Regent Park area.

Providing an efficient, cost-effective structural system that would accommodate the CRC's functional requirements was essential to successful project delivery. The solution that Halsall Associates proposed to CRC and Hilditch Architect of Toronto was outside the box: a Staggered Truss system.

The team recognized, however, that the system would present a number of construction challenges. Topping the list was the fact that this framing system was last used in Canada around 20 years ago and was not generally familiar to contractors.

The concept of Staggered Trusses was developed in the 1960s at the Massachusetts Institute of Technology (MIT). The system has proved to be a practical and efficient framing system for mid-rise apartments, motels, dormitories and similar buildings. Low floor-to-floor height helps reduce the cost of the building envelope and is achieved in part by the use of precast slabs that provide a large depth-to-span ratio. Construction times are reduced due to the simplicity of truss fabrication and construction. The result is an effective, low-cost structural system.

Staggered Truss System at 40 Oak Street under construction

40 Oak Street

Certain features of the building at 40 Oak Street made it suitable for the use of the Staggered Truss system: its rectangular shape, its floor plan and its height.

The building has five storeys and a basement, with a total area of approximately 70,000 square feet. The main floor houses the headquarters of the CRC, a community kitchen and 10,000 square feet of flexible, multipurpose space. This flexibility is achieved by a column-free main level; the layout can be easily modified to meet future program needs.

The upper levels accommodate 87 units of affordable housing divided into bachelor, one-bedroom and two-bedroom units. Amenity space is located on the second level. A circular two-storey room provides worship space for the community. Mechanical rooms and bicycle storage are located in the basement.

The building was designed to meet Toronto's Green Development Standard at a level equivalent to LEED Silver.

In a typical Staggered Truss system, trusses spanning the width of the building are located every other gridline, and their location is shifted one bay the next level up. In this way, each truss supports two levels at a time, one on each chord; the depth of the truss is equal to the floor-to-floor height (Figure1).

With such an arrangement, columns are only required along the long sides of the rectangular floor plan, creating an opportunity for a column-free ground floor if trusses are not used between the ground and second floor, as in the case of 40 Oak Street.

The ideal building layout to take full advantage of Staggered Trusses has gridlines equally spaced; however, in reality such buildings are rare. At the east and west ends of 40 Oak Street, grid spacing differs from the equally spaced middle portion of the building to accommodate stairs, the elevator core and the double-height worship space. For this reason, the Staggered Truss arrangement at both ends of the building departs from the ideal configuration (Figure 2).

The structure

Basement and ground floor slab at 40 Oak Street is conventional cast-in-place concrete. Precast slabs form the floor from the second floor to roof level. Precast slabs are the best option for a Staggered Truss system to maintain the speed and simplicity of construction and keep the building height to a minimum. At 40 Oak Street, the typical bay is 9.6m, and 200mm-thick precast slabs with 50mm topping are used. The distance between trusses in a typical floor is 19.2m (9.6m x 2), providing large structure-free spaces.

The trusses at 40 Oak Street have a span of 16.8m and a height of 2.7m. Both chords are W250 sections; verticals and diagonals are W200, and columns are W310 sections. These sizes were coordinated with the architectural design so the trusses could be hidden in walls.

When Staggered Trusses are used from the ground floor up, they can serve as

Figure 1: Typical Staggered Truss system – vertical stacking arrangement

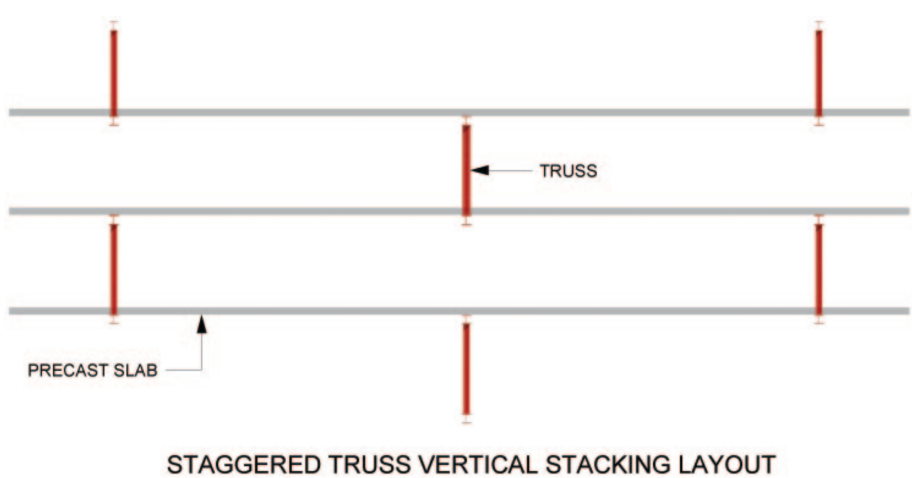
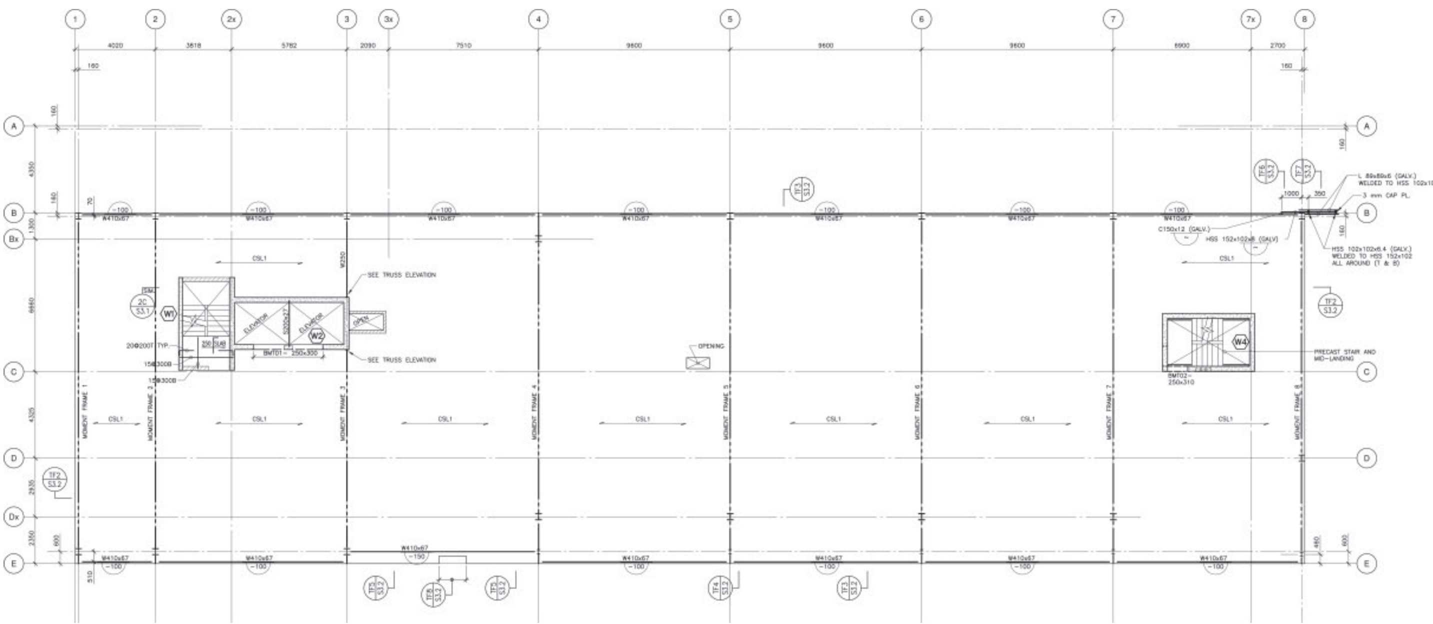


Figure 2: 40 Oak Street – typical floor plan



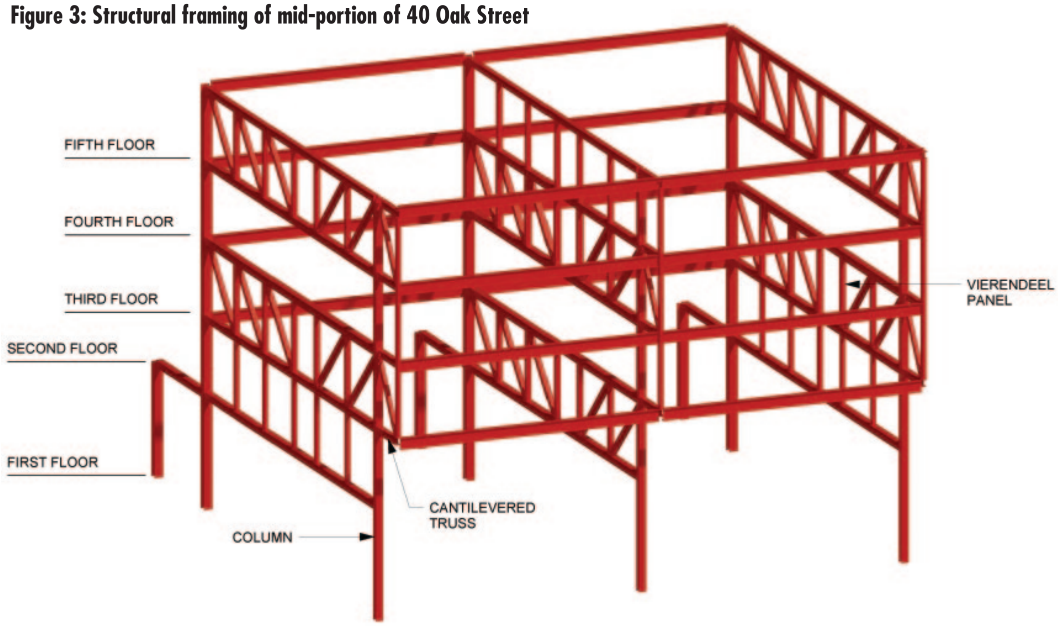
the structure's lateral system. However, to maintain a column-free ground level at 40 Oak Street, cast-in-place concrete cores provide the structure resistance framing system (elevator and east stair). Although the trusses do not extend to the ground level, they add lateral stiffness to the upper levels. During the structural analysis, close attention was paid to ensure proper behaviour of the lateral system and to identify the additional forces induced to the trusses from wind and earthquake.

To achieve a column-free ground floor, we used hangers from trusses located between Levels 3 and 4 to support the second floor. Similarly, to maintain the staggered truss layout and optimize steel tonnage, we supported the roof structure on alternate gridlines with posts seated on top of trusses provided between levels 4 and 5. These special combination trusses were therefore designed to support three levels (Figure 3).

Another important feature of the Staggered Truss system is the use of Vierendeel panels to create openings in the trusses to facilitate circulation inside the building. At 40 Oak Street, these panels are used almost at the mid-span of the trusses to create a corridor along the long dimension of the building. Similar panels are used at the east and west end frames to accommodate windows. This required close coordination with the architectural design to provide the building with natural light and ventilation to meet sustainability requirements while maintaining structural integrity.

At 40 Oak Street, the soil conditions and the load carried by the columns required the use of bored concrete piles. Since Staggered Trusses require only two columns for every frame, the number of bored piles was minimized, reducing construction costs.

Figure 3: Structural framing of mid-portion of 40 Oak Street



Construction

With input from Buttcon Limited, the general contractor, and Steelcon Fabrication Inc., it was decided that the fastest way to build 40 Oak Street was by casting the elevator and stair cores from foundation to roof using sliding forms, then erecting the structural steel. The columns were erected in two sections, three and two storeys. Then trusses were connected to the columns and finally the precast slabs were "dropped" in place. This process was simple, efficient and fast.

In the original design, the intention was to support the precast slabs on the bottom flange of the W250 truss chords—in this way the chords would be hidden within the slab leaving a flat soffit and minimizing the size of drop ceilings for mechanical pipes and ducts in corridors. The precast slab supplier suggested, however, that supporting the slabs on the top flange would simplify the erection process and would be more cost-effective. The design details were modified to accommodate this change.

In conclusion, the use of the Staggered Truss system at 40 Oak Street helped reduce project costs and accelerate construction. The system was also appropriate for the building's functional requirements: CRC was pleased with the flexibility the structure-free spaces provided, and modifications can be made in the future as program requirements change.

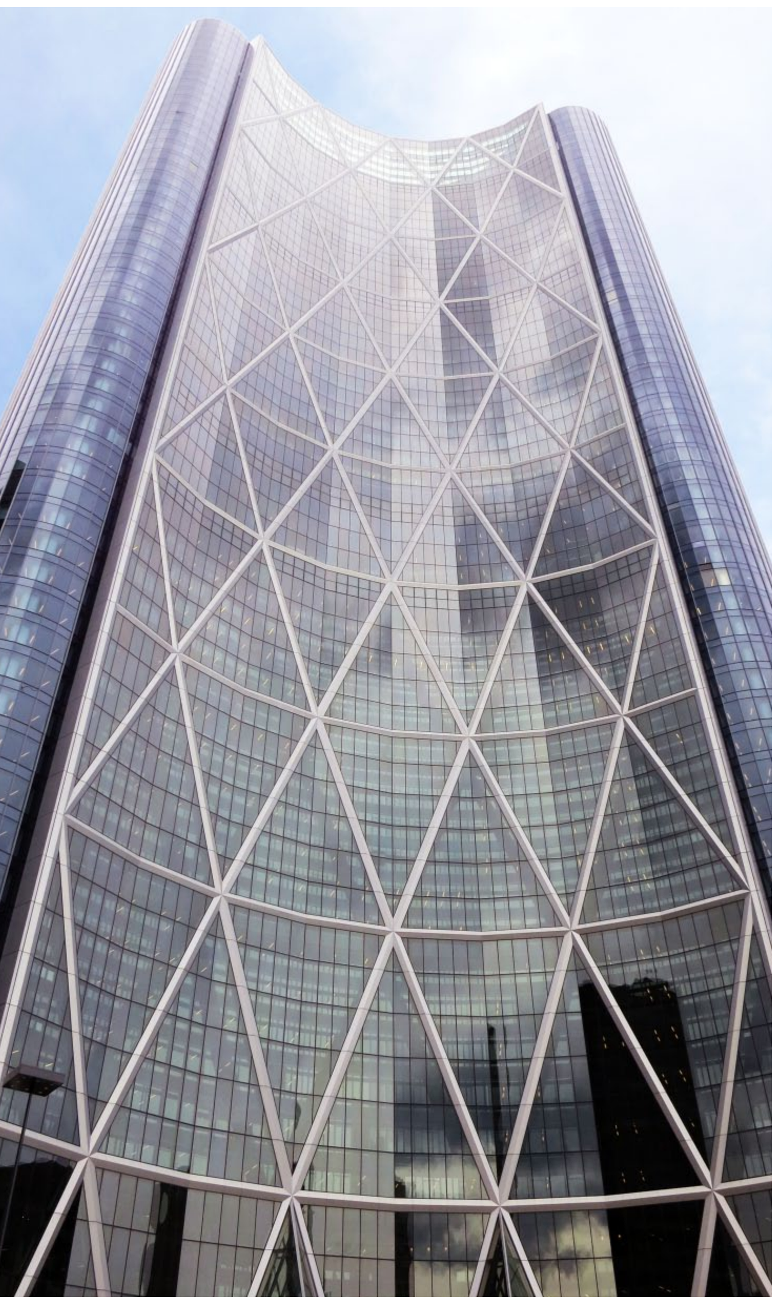
There was some initial uncertainty about the integrity of the system during the construction stage. In the end, however, the system proved to be a good example of thinking outside the box to provide an efficient and cost-effective structural solution.

Fernando Cruz, M.Eng., P.Eng., is a Project Manager with Halsall Associates in Toronto. He has 13 years of experience in structural engineering, and has participated in many large projects involving use of structural steel in Canada and overseas.

Michael Jelicic, P.Eng., is a Project Principal with Halsall Associates in Toronto.

2012 CISC National Steel Design Awards

Three commendable construction projects gain special recognition



The Canadian Institute of Steel Construction (CISC) announced the winners of its biennial National Steel Design Awards competition during a gala dinner at its Annual General Meeting & Convention in Ottawa last June.

The prestigious National Design Awards are open to architects, engineers, developers, owners and other stakeholders involved with a building, bridge, industrial or other steel work project in which engineering demands, architectural considerations or sustainability requirements influenced the designer's choice of steel as the most appropriate structural solution.

The awards are a culmination of a two-year competition that brings together regional winners from across the country in three award categories: Architecture, Engineering and Sustainability.

The award winners for 2012 are outlined below.

ENGINEERING

The Bow, Calgary, Alberta
Iconic Calgary office tower is unique in North America

OWNER: H&R REIT

ARCHITECT: Foster + Partners in collaboration with Zeidler Partnership Architects

STRUCTURAL ENGINEERS: Halcrow Yolles

GENERAL CONTRACTOR: Ledcor Construction Ltd. (Construction Manager)

CISC FABRICATOR, DETAILER & ERECTOR:
Supreme Steel in joint venture with Walters Group

The Bow, the iconic crescent-shaped office tower rising on the east side of Calgary's downtown core, has provided a spectacular show for Calgarians during its construction. Spectators might not have realized they are also witnessing a North American first.

The Bow is unique on the continent in its application of a triangular steel diagrid system to a curved building. The diagrid, composed of six-storey-high diagonal elements, creates a perimeter frame of linked equilateral triangles curved to match the bow of the building on the north and south faces.

The external structural system frees up more floor space than a traditional building, and the diagrid design also significantly reduces the amount of steel required compared to a conventional structure. The crescent-shaped floor plan increases the number of perimeter offices that are possible and improves access to natural light.

"The curve had its own rationale," says Stephen Carruthers, Managing Partner, Western Canada, Zeidler Partnership Architects. "It also decreases the wind resistance that would be associated with a rectangular building of the same size. It's an aerodynamic shape that allows the wind to slip around the curve, much like the wing of an airplane.

"The curve is also intended to be a sun catcher. It orients the building to the southwest to capture maximum sun and gives occupants a more direct view of the mountains."

The combination of the crescent shape and diagrid system necessitated a faceted curtain wall solution, Carruthers says. "What would be a straightforward rectilinear geometry in a conventional office tower suddenly becomes very subtle geometry. Because of the curvature, each steel member of the diagrid had to connect into a node at very precise angles and with very exacting tolerances.

"It was a very tense moment when the first node was set into place. We were all very anxious that it should fit perfectly. The first one dropped into place beautifully. Everyone heaved a sigh of relief. From that point on we said: 'This is going to go well.'"

Another unique aspect of The Bow is the series of three multi-storey "sky gardens" located at each of the elevator transition floors. The sky gardens provide all the common-use facilities such as copy shops, coffee and snack kiosks, and generous seating areas.

"The sky gardens will become like village squares where employees can sit under trees, have coffee with their colleagues and exchange ideas," Carruthers says. "They will be quite grand. The floor structure allowed us to put tree pits into the floors so we can plant full-size trees. These 'forests' were enabled by the steel structure and will be visible as you look up at the building, particularly at night when the trees are illuminated.

"All of these features combined will ensure that The Bow will become Calgary's premier landmark. It is going to be spectacular."

ARCHITECTURE

The Art Gallery of Alberta
Building is a work of art in steel

ARCHITECTS: Randall Stout Architects, Inc. and HIP Architects, Associate Architect

STRUCTURAL ENGINEERS: DeSimone Consulting Engineers and BPTEC-DNW Engineering Ltd.

CISC FABRICATOR /DETAILER / ERECTOR AND ENGINEER: Empire Iron Works Ltd.

GENERAL CONTRACTOR: Ledcor Construction Limited

Sinuous stainless steel surfaces and complex curving geometry inspired by the aurora borealis render the Art Gallery of Alberta a work of art in itself.

The project, on the edge of Edmonton's downtown Churchill Square, is a renovation of the existing concrete building intended to create expanded, flexible, museum-quality space for the gallery's permanent collection and major travelling exhibitions. The renovation consisted of a two-storey vertical addition above the existing building to contain gallery space and offices, and the addition of an atrium that exhibits the creative and dramatic use of steel to invoke the borealis.

Structural steel was the obvious choice for the vertical addition because it minimized the impact on the existing

structure, reduced loads on the foundation, and provided unimpeded column-free interior space to maximize flexibility for exhibitions. The entire addition is supported by only six columns located on the north and south perimeters.

The building envelope of the atrium is formed from angular, transparent glazing planes penetrated by curving, reflective metal-clad elements that create the borealis. "You couldn't do that with anything other than structural steel because of the complexity of the shapes," says Trevor Hobbs, Detailing and Technical Lead, Empire Iron Works.

Construction of the atrium presented numerous challenges due to the complex geometry, Hobbs says. "While the structure itself looks quite light and airy, we were dealing with heavy loads and members that had to line up with each other precisely. Both exposed and concealed connections required special attention due to the 3D aspect, the aesthetics and the close proximity of other building elements. This was most difficult where the skin fit tightly to the structure and restricted the space we could work with."

Adding to the challenges, the borealis edging panels were pre-fabricated in St. Louis and then attached to brackets on the steel framing on site. "We had to make sure the structural steel was correct and that the brackets were in the correct locations. It's a shame it's covered up, because it's by far the best part," Hobbs says.

Ensuring museum-quality, climate-controlled interior space demanded a high-performance building envelope. This requirement created a challenge where architectural features were designed to penetrate the envelope.

"Some elements of structural steel were cantilevered through the skin," Hobbs says. "Because steel is a good thermal conductor, this could compromise the museum quality space. The team resolved this issue by incorporating a thermal break in the steel at the point where it penetrates the building envelope and adding a non-conducting material in the joint to isolate the interior steel from the exterior steel."

A large measure of the success of the project is due to teamwork and the use of a variety of emerging techniques in 3D modelling to coordinate and communicate the design details necessary for efficient site construction, Hobbs says.

"Everybody used different programs and there were many files transferred back and forth. It was a really good project in terms of the level of teamwork that we achieved."

SUSTAINABILITY

Dawson Bridge Rehabilitation, Alberta

Innovative steel deck turns historic bridge into modern world leader

OWNER: City of Edmonton

ENGINEER: DIALOG

FABRICATORS/DETAILERS: Empire Iron Works Ltd. and Steel Design and Fabricators Ltd.

STEEL ERECTOR: Steel Design and Fabricators Ltd.

While Edmonton's Dawson Bridge has been in service for nearly 100 years, innovative technology used in its recent rehabilitation has turned it into a modern world leader.

The five-span riveted steel through-truss bridge was originally built to carry electric trains to a coal mine on the east bank of the North Saskatchewan River. Later converted to carry automobiles, the bridge currently accommodates 17,000 vehicles per day along with significant pedestrian and cyclist traffic.

After almost a century of use, the bridge needed significant repair, including total deck replacement and truss repainting. Numerous truss members required strengthening or replacement to provide an appropriate level of safety and extend the service life of the bridge.

The Dawson Bridge is listed on the Inventory of Historical Resources in the City of Edmonton. This designation means that any modifications to the bridge must be carried out in a manner that respects historical aspects of its appearance.

"We did our homework," says Kris Lima, Structural Engineer with DIALOG,

design consultant on the project. "Our analysis showed that numerous truss members needed to be strengthened or replaced to increase the safety of the structure. It also showed that the strengthening work could be reduced significantly by limiting the dead load on the bridge."

The design team chose a lightweight composite steel plate and elastomer deck system using a technology originally developed for the marine industry and only recently applied to bridge construction. The system basically consists of two thin steel face plates connected by an injected elastomer core, for a total thickness of only 45 mm in the case of the Dawson Bridge.

"This deck system is light compared to a conventional deck system," Lima says. "By using this system, we were able to reduce by more than half the number of members needing strengthening or replacement to bring the bridge up to current safety standards.

"Only a handful of bridges have been built using this technology. The Dawson Bridge project is the first major project in the world of this scale to incorporate this innovative system."

The Dawson Bridge scored another technological first with its connection details. "All the other bridges using this deck technology involved significant field welding, which is costly and difficult to maintain quality," Lima says. "As part of our intensive risk control program, we set out to develop new connection details between adjacent deck panels which would eliminate the need of all welding on site."

The result is an innovative bolting system that involves using splice plates to connect adjacent deck panels with countersunk bolts, allowing the panels to be quickly bolted into position on the bridge. "We conducted laboratory testing on the bolting to estimate the long-term fatigue performance of the connections," Lima says. "Those tests demonstrated that the new connection detail can withstand fatigue loads nearly double in magnitude to those expected in actual in-service conditions." The Dawson Bridge is the first project in the world to use this unique bolting system.

The use of the innovative deck system on the Dawson Bridge project has successfully advanced the state of the art in bridge technology and has achieved cost savings for the City of Edmonton, while allowing the rehabilitation work to be completed within a single construction season.

News and Events

CISC Ontario Chair honoured

CISC Ontario Chairman John Rogers of Kubes Steel Inc. was recently honoured by the Rotary Club of Ancaster AM, which presented him with a Rotary International Paul Harris Fellowship for his contributions to the world community as Chairman of the Golden Horseshoe Children of Chernobyl charity. The event took place at a gala award dinner on March 30 at the iconic Hamilton Golf and Country Club.

The Paul Harris Fellowship is Rotary's highest honour and is bestowed on Rotarians and members of the community whose contributions most emulate Rotary's precept of "Service before Self." Golden Horseshoe Children of Chernobyl brings children to Canada from areas of Belarus that were contaminated with radioactive fallout from the Chernobyl nuclear disaster. The purpose of the visits is to flush the effects of long-term radiation from their bodies and allow their immune systems to rebuild.

Over the past eight years, John Rogers and his wife Julie have hosted as many as three children at a time for up to three months each summer. One of those children, Tanya Kapuza has become a regular visitor to the CISC AGM each June. Rogers has become one of Canada's most stalwart advocates for the plight of the children of Chernobyl. He has travelled to Eastern Europe on five occasions and spent almost two months living in the villages with the families in the contaminated areas of Belarus.

John Rogers of Kubes Steel Inc. receives the Rotary International Paul Harris Fellowship

Congratulations to Wilfrid Morin

Quebec's Wilfrid Morin has received the 2012 Gold Medal from Engineers Canada. The award is the highest of its kind in the country. Morin is a Consulting Engineer who headed Teknika HBA and oversaw its merger, which created exp. Under his leadership Teknika HBA was listed among Quebec's best employers and among the 50 best-managed companies in Canada.

Halcrow Yolles

Yolles moves forward as a CH2M HILL company. Founded by Morden Yolles in 1952, Yolles has gone through many changes over the past few years since being acquired by Halcrow in 2004. Following CH2M HILL's acquisition of Halcrow last November, a decision was made to return as Yolles, a CH2M HILL company.

Read Jones Christoffersen

Leadership succession at Read Jones Christoffersen (RJC) took a step forward in 2012. Rob Colwell has taken over the role of Managing Principal for the Calgary Structural Engineering Team. The firm also announced the appointment of new Principals and Associates. From RJC Calgary, new Principals are Doug Little, Phil Parker and Simon Brown. From RJC Edmonton, new Principals are Frank Cavaliere and Jeff Rabinovitch. Newly appointed Associates are Leonard Pianalto from RJC Vancouver, and Enzo Vercillo and Jamie Murphy from RJC Edmonton. RJC opened two new Ontario-based offices in Kingston and Kitchener, as well as one new office in Lethbridge, Alberta.

Samuel, Son & Co., Limited

In 2012, Samuel, Son & Co., Limited marks its 157th year in the metals distribution industry, as well as the 12th year of Wayne Bassett as CEO. Samuel also opened an East Coast Service Centre in Darmouth this year. Bombardier Recreational Products (BRP) awarded Samuel et Fils (Quebec operations) its highest award, the Gold Plaque for Customer Service, in 2011.

Continuing Education Courses

Along with our ongoing calendar of courses, CISC is pleased to present two new English language courses in 2013 that lead to CISC Accreditation in a specific field, which is new for CISC and supports our commitment to quality steel construction. The 3-day Inspection of Steel Building Structures course and examination leads to a CISC Accredited Steel Inspector – Steel Structures/Buildings qualification, and the Connections II course and examination leads to a CISC Accredited Steel Connections Designer – Conventional Construction qualification. An accreditation program for the inspection of steel bridges is under development.

For full course schedule, information, online registration and the latest updates, please visit our website at www.cisc-icca.ca/courses, or request a copy of our course calendar.

Statics and Strength of Materials
– New Online Course –

This twice-weekly evening course is the prequel to the two-part "Connections" series and is intended to prepare students who do not have a structural engineering background for the design of steel connections. The basic principles of statics and strength of materials will be introduced with application to simple structures. It will also include terminology specific to this specialty along with the source of rules and standards used in the steel industry. It will be of interest to steel detailers, designers and steel fabrication engineers new to the industry or just needing a refresher.

Course Leader: Pete Birkemoe, University of Toronto

Webinar Format (20@3hrs)
Tuesdays and Thursdays, 6:00 p.m. to 9:00 p.m. ET
starting October 2, 2012

Industrial Building Design

This course is intended to provide understanding on design theory and the rationale behind code provisions that are unique to steel-framed industrial buildings. It focuses on practical and economical solutions for framing a typical industrial building to the requirements of the 2010 National Building Code of Canada and the pertinent provisions of CSA Standard S16-09.

The learning goals for this course include the following: to identify the unique environmental and mechanical loading conditions in industrial buildings, learn the applicability and limitations of current codes and standards in Canada, select the most cost-effective framing schemes, design crane-supporting girders, stepped columns, purlins and girts, explore lateral force resisting systems, roof trusses and efficient connections, understand serviceability considerations and limitations, design for high and low temperatures, learn the implications of seismic provisions, plus other topics such as fatigue, standing seam roofs, rehabilitation, tolerances and coatings.

The course leaders for the English language edition are:
Robert A. (Bob) MacCrimmon, P.Eng., Senior Civil/Structural Specialist, Hatch; and
Greg Miazga, P. Eng.,
Vice President Engineering, Waiward Steel Fabricators Ltd.

The course schedule is as follows:

Toronto, ON	September 26
Saskatoon, SK	September 27
Edmonton, AB	October 2
Calgary, AB	October 3
Vancouver, BC*	October 4

**In partnership with APEGBC*

Hot Topic Webinars
- New Online Series –

This series of 1.5-hr. webinars is intended to provide information on the most heavily discussed topics in the construction industry today, but not covered in any detail in continuing education courses. Guest speakers are subject matter specialists with the necessary knowledge and experience to provide insight and solutions.

The presenters define the problem, list the issues and positions, provide background information, explain regulatory requirements, use case studies to illustrate how they or others have dealt with the issues and provide references to additional resources.

CISC Costing Method for Steel Structures
November 6, 1:00 - 2:30 p.m. ET
Thor Gaul, TPG Enterprises Ltd.

LEED Credits MR 4 + 5
November 28, 1:00 - 2:30 p.m. ET
Sylvie Boulanger, Supermétal Structures Inc.

Steel Design for Low Seismicity
December 14, 11:00 a.m. -12:30 p.m. ET
Alfred Wong, CISC

Changes to CSA S16-09 & Steel Handbook Highlights
– Online Course –

This course covers the changes in CSA S16-09 and the design of steel members and elements using the recently published 10th Edition of the Handbook of Steel Construction. It is presented online in four two-hour sessions. Registration can include all four sessions with 0.8 CEUs awarded upon completion, or the CSA S16-09 session alone with 0.2 CEUs awarded upon completion. In addition, discounted bundles with the Handbook and CISC Membership are available at registration.

December 11 & 12 12:00 - 2:00 p.m. and 3:00 - 5:00 p.m. ET

Seismic Design of Steel-Framed Buildings
– Renewed Course –

Held in tandem with the Seismic Connections for Steel-Framed Buildings course, this course is intended to provide understanding on design theory and application of specific Code formulae for seismic force resisting systems in steel-framed buildings to the requirements of the 2010 National Building Code of Canada and the pertinent provisions of CSA Standard S16-09.

New topics include ductile plate walls, buckling-restrained braces and higher limits for conventional construction. Updated topics include tension-only braced frames, concentrically braced frames, ductile eccentrically braced frames, Type LD moment resisting frames, ductile moment resisting frames, notional loads, P-delta effects and diaphragms.

Seismic Connections for Steel-Framed Buildings
– New Course –

Held in tandem with the Seismic Design of Steel-Framed Buildings course, this course prepares consulting structural engineers and steel fabrication engineers for the design of connections in ductile Seismic Force Resisting Systems in steel-framed buildings to the requirements of the 2010 National Building Code of Canada and Clause 27 of CSA Standard S16-09. The critical connections in the design examples developed for the Seismic Design of Steel-Framed Buildings course are used.

Capacity design requirements, now well entrenched in Clause 27 of S16-09, have virtually revolutionized the design, detailing and construction of connections for seismic applications. These requirements make it almost impossible to design Seismic Force Resisting Systems in isolation since the overall behaviour of these frames is highly dependent on the configuration and proportioning of these connections. The course will take participants through the detailed design of connections for moment connections covered in the CISC publication, Moment Connections for Seismic Applications, links and brace connections in Eccentric Braced Frames, tension-compression brace connections, tension-only brace connections, and more.

Course leaders are:
Alfred F. Wong, M.Eng., P.Eng.,
Director of Engineering, CISC; and
Larry S. Muir, M.S.C.E., P.E., President,
The Steel Connection, LLC

Fredericton, NB	September 10 & 11
Halifax, NS	September 12 & 13
Toronto, ON	December 3 & 4
Vancouver, BC	December 6 & 7

Nouveautés CSA S16-09 et survol du Handbook

Ce cours traite des modifications apportées à la norme CSA S16-09 et au dimensionnement des charpentes métalliques à l'aide de la 10e Édition du « Handbook of Steel Construction ». Ce cours est proposé en ligne, en quatre séances de deux heures, via le système GoToWebinarMC. Les personnes intéressées peuvent s'inscrire aux quatre séances (0,8 UFC/CEU seront accordés à la fin du cours), ou à la séance unique sur la norme CSA S16-09 (0,2 UFC/CEU seront accordés à la fin du cours). De plus, des offres de remise groupées avec le « Handbook » et l'adhésion à l'ICCA seront proposées aux participants lors de l'inscription.

Le cours de formation continue de l'ICCA, Nouveautés CSA S16-09 et survol du « Handbook », est présenté en ligne (webinaire) en quatre séances de deux heures comme suit.

16 octobre
12 h - 14 h et 15 h - 17 h (HAE)

17 octobre
12 h - 14 h et 15 h - 17 h (HAE)

Conception, fabrication et construction de ponts en acier

Ce cours traite de la conception, de la fabrication et de la construction de ponts en acier selon la norme CAN/CSA-S6-06, Code canadien sur le calcul des ponts routiers, supplément no #1. Ce cours a pour but d'aider à mieux comprendre la théorie de conception et le raisonnement des dispositions du code ainsi que l'application de certaines formules et exigences du Code. Les aspects pratiques et économiques de la fabrication, du montage, du choix des matériaux et leurs conséquences sur la conception seront également mis en évidence.

Montréal, QC	19 et 20 novembre
Québec, QC	21 et 22 novembre

New Members and Associates

At the June meeting, the CISC Board of Directors elected the following organizations as new members and associates. Welcome all!

Professional Individual
Timothy P. Fraser,
Jonathan R. Lambert,
Iain J. Cameron,
Mohamed Matar,
Thomas H. Leung

Associate Company
Pier Structural Engineering Corp., Waterloo, ON

Associate Supplier
Steel Plus Network, Edmonton, AB
Coface Canada Collections Corp., Toronto, ON

Associate Fabricator
Sperling Industries Ltd., Sperling, MB

Old Tymer Welding, Orillia, ON

Ganawa Bridge Products and Services, Ajax, ON

Regional Events

Quebec
4th Annual Steel Workshop and 2012 Design Awards Gala
With special Master of Ceremony,
Sylvie Frechette, Olympic Gold Medalist

September 27, 2012
Palace Convention Centre, Laval, QC
www.quebec.cisc-icca.ca

For more information and to purchase tickets contact Hellen Christodoulou at:

quebec@cisc-icca.ca (514) 909-6186

Events

Steel Day
September 28, 2012
Various locations across Canada
www.steelday.ca

SMMH 2012 – Structures for Mining and Related Materials Handling Conference
October 15 - 18, 2012, Vanderbijlpark, South Africa
www.smmh2012.co.za

NASCC: The Steel Conference
April 17 - 20, 2013, St. Louis, Missouri
www.aisc.org/nascc

CISC Member Directory - Listing as of July 23, 2012

Legend:
**sales office only*
B Buildings
Br Bridges
S Structural
P Platework
J Open-web Steel Joist

FABRICATOR

ATLANTIC

Cherubini Metal Works Limited P, S
Dartmouth, Nova Scotia 902-468-5630
www.cherubinigroup.com

Eascan Building Systems Ltd.
Truro, Nova Scotia 902-897-9553
www.eascan.ca

Groupe Canam inc.
Moncton, New Brunswick 506-857-3164
www.canam.ws

MacDougall Steel Erectors Inc. S
Cornwall, Prince Edward Island 902-855-2100
www.macdougallsteel.com

Marid Industries Limited S
Windsor Junction, Nova Scotia 902-860-1138
www.marid.ns.ca

Modular Fabrication Inc.
Miramichi, New Brunswick 506-622-1907
www.modularfab.com

MQM Quality Manufacturing Ltd. P, S
Tracadie-Sheila, New Brunswick 506-395-7777
www.mqm.ca

Ocean Steel & Construction Ltd. Br, P, S
Saint John, New Brunswick 506-632-2600
www.oceansteel.com

Prebilt Structures Ltd. P, S
Charlottetown, Prince Edward Island 902-892-8577
www.prebiltsteel.com

RKO Steel Limited P, S
Halifax, Nova Scotia 902-468-1322
www.rkosteel.com

Tek Steel Ltd. S
Fredericton, New Brunswick 506-452-1949

QUEBEC

Acier Fortin Inc. S
Montmagny, Quebec 418-248-7904
www.acierfortin.com

Acier Métaux Spec. inc. S
Chateauguay, Quebec 450-698-2161
www.metauxspec.ca

Acier Robel inc. S
St-Eustache, Quebec 450-623-8449
www.acierrobel.com

Alma Soudure inc. S
Alma, Quebec 418-669-0330
www.almasoudure.com

Charpentes d'acier Sofab Inc. S
Boucherville, Quebec 450-641-2618
www.sofab.ca

Charpentes Métalliques TAG (6541984 Canada inc.) S
Ange-Gardien, Quebec 450-379-9661

Constructions PROCO Inc. S
St. Nazaire, Quebec 418-668-3371
www.proco.ca

Groupe Canam inc. J, S
Ville de St-Georges, Quebec 418-228-8031
www.canam.ws

Lainco Inc. B, Br, S
Terrebonne, Quebec 450-965-6010

Les Aciers Fax inc. B, S
Charlesbourg, Quebec 418-841-7771

Les Constructions Beauce-Atlas inc. S
Ste-Marie de Beauce, Quebec 418-387-4872
www.beauceatlas.ca

Les Industries V.M. inc. S
Longueuil, Quebec 450-651-4901

Les Structures C.D.L. Inc. S
St-Romuald, Quebec 418-839-1421
www.structurescdl.com

Les Structures GB Ltée P, S
Rimouski, Quebec 418-724-9433
www.structuresgb.com

Métal Moro inc. S
Montmagny, Quebec 418-248-1018

Métal Perreault Inc. B, P, S
Donnaconna, Quebec 418-285-4499
www.metalperreault.com

Mometal Structures Inc. B, S
Varennes, Quebec 450-929-3999
www.mometal.com

NGA Structure Inc. B, S
Drummondville, Quebec 819-477-6891
www.nga.qc.ca

Produits Métalliques PMI S
Rimouski, Quebec 418-723-2610
www.pmibuilding.com

Quirion Métal Inc. S
Beauceville, Quebec 418-774-9881
www.quirionmetal.com

Ray Metal Joliette Ltée S
Joliette, Quebec 450-753-4228

Structal Bridges, A Division of Canam Group Inc. P, S
Quebec, Quebec 418-683-2561
www.structalponts.ws

Structal-Heavy Steel Construction- A division of Canam Group Inc. [Boucherville] J, S
Boucherville, Quebec 450-641-4000
www.canam.ws

Sturo Metal Inc. S
Lévis, Quebec 418-833-2107
www.sturometal.com

Supermétal Structures Inc. P, S
St-Romuald, Quebec 418-834-1955
www.supermetal.com

Tecno Metal Inc. B, S
Quebec, Quebec 418-682-0315
www.tecnometal.ca

ONTARIO

A.J. Braun Mfg. Limited Br
Kitchener, Ontario 519-745-5812
www.ajbraun.com

AAP Steel Inc.
Vaughan, Ontario 905-669-2274
www.aapsteelinc.net

AC Metal Fabricating Ltd.
Oldcastle, Ontario 519-737-6007

ACL Steel Ltd. S
Kitchener, Ontario 519-568-8822
www.aclsteel.ca

Arkbro Structures
Mississauga, Ontario 905-766-4038

Austin Steel Group Inc. S
Brampton, Ontario 905-799-3324
www.gensteel.ca

Azimuth Three Enterprises Inc. S
Brampton, Ontario 905-793-7793

Benson Steel Limited J, S
Bolton, Ontario 905-857-0684
www.bensonsteel.com

Burnco Mfg. Inc. S
Concord, Ontario 905-761-6155
www.burncomfg.com

C & A Steel (1983) Ltd. S
Sudbury, Ontario 705-675-3205
www.casteel1983.com

C_ore Metal Inc.
Oakville, Ontario 905-829-8588
www.coremetal.com

Central Welding & Iron Works Group P, S
North Bay, Ontario 705-474-0350
www.centralwelding.ca

Cooksville Steel Limited [Kitchener] S
Kitchener, Ontario 519-893-7646
www.cooksvillesteel.com

Cooksville Steel Limited [Mississauga] S
Mississauga, Ontario 905-277-9538
www.cooksvillesteel.com

D & M Steel Ltd. S
Newmarket, Ontario 905-836-6612

Eagle Bridge Inc. S
Kitchener, Ontario 519-743-4353
www.eaglebridge.ca

Ed Lau Ironworks Limited S
Kitchener, Ontario 519-745-5691
www.edlau.com

Fortran Steel Inc. S
Greely, Ontario 613-821-4014
www.fortransteel.com

G & P Welding and Iron Works P, S
North Bay, Ontario 705-472-5454
www.gpwelding.com

Gorf Manufactuing/Contracting Ltd. P, S
Porcupine, Ontario 705-235-3278
www.gorfcontracting.net

Group Canam Inc. J, S
Mississauga, Ontario 905-671-3460
www.canam.ws

IBL Structural Steel Limited B
Mississauga, Ontario 905-671-3301
www.iblsteel.com

Lambton Metal Services S
Sarnia, Ontario 519-344-3939
www.lambtonmetalservice.ca

Laplante Welding of Cornwall Inc. S
Cornwall, Ontario 613-938-0575
www.laplantewelding.com

Linesteel (1973) Limited B, S
Barrie, Ontario 705-721-6677

Lorvin Steel Ltd. S
Brampton, Ontario 905-458-8850
www.lorvinsteel.com

M&G Steel Ltd. S
Oakville, Ontario 905-469-6442
www.mgsteel.ca

M.I.G. Structural Steel (Div. of 3526674 Canada Inc.) S
St-Isidore, Ontario 613-524-5537
www.migsteel.com

Maple Industries Inc. S
Chatham, Ontario 519-352-0375
www.mapleindustries.ca

Mariani Metal Fabricators Limited S
Etobicoke, Ontario 416-798-2969
www.marianimetal.com

MBS Steel Ltd. J
Brampton, Ontario 905-799-9922
www.mbssteel.com

Mirage Steel Limited J, S
Brampton, Ontario 905-458-7022
www.miragesteel.com

Norak Steel Construction Limited S
Concord, Ontario 905-669-1767
www.noraksteel.com

Paradise Steel Fab. Ltd. S
Richmond Hill, Ontario 905-770-2121

Paramount Steel Limited S
Brampton, Ontario 905-791-1996
www.paramountsteel.com

Pittsburgh Steel Group S
Mississauga, Ontario 905-362-5097
www.pittsburghsteel.com

Quad Steel Inc. S
Bolton, Ontario 905-857-9404
www.quadsteel.ca

Quest Steel Inc. B, Br, P, S
Mississauga, Ontario 905-564-7446

Refac Industrial Contractors Inc. P, S
Harrow, Ontario 519-738-3507
www.refacindustrial.com

Resource Industrial Group Inc. Br, P
Ayr, Ontario 519-622-5266
www.resourceindustrial.com

Shannon Steel Inc. S
Orangeville, Ontario 519-941-7000
www.shannonsteel.com

Steel 2000 Inc. S
Chelmsford, Ontario 705-855-0803

Steelcon Fabrication Inc. B
Bolton, Ontario 416-798-3343

Telco Steel Works Ltd. S
Guelph, Ontario 519-837-1973
www.telcosteelworks.ca

Tower Steel Company Ltd. S
Erin, Ontario 519-833-7520
www.towersteel.com

Tresman Steel Industries Ltd. S
Mississauga, Ontario 905-795-8757
www.tresmansteel.com

Victoria Steel Corporation S
Oldcastle, Ontario 519-737-6151

Walters Inc. P, S
Hamilton, Ontario 905-388-7111
www.waltersinc.com

MANITOBA

Abesco Ltd. S
Winnipeg, Manitoba 204-667-3981

Capitol Steel Corp. S
Winnipeg, Manitoba 204-889-9980
www.capitolsteel.ca

Coastal Steel Construction Limited P, S
Thunder Bay, Ontario 807-623-4844
www.coastalsteel.ca

Shopost Iron Works (1989) Ltd. S
Winnipeg, Manitoba 204-233-3783
www.shopost.com

Saskatchewan

Elance Steel Fabricating Co. Ltd. S
Saskatoon, Saskatchewan 306-931-4412
www.elancesteel.com

IWL Steel Fabricators Ltd. P, S
Saskatoon, Saskatchewan 306-242-4077
www.iwlsteel.com

JNE Welding Ltd. P, S
Saskatoon, Saskatchewan 306-242-0884
www.jnewelding.com

Supreme Group Inc. [Saskatoon] P, S
Saskatoon, Saskatchewan 306-975-1177
www.supremesteel.com

Weldfab Ltd. S
Saskatoon, Saskatchewan 306-955-4425
www.weldfab.com

ALBERTA

AAA Steel Limited
Calgary, Alberta 403-236-4625
www.aaasteel.com

Anglia Steel Industries (1984) B, P, S
Calgary, Alberta 403-720-2363
www.angliasteel.ca

Bow Ridge Steel Fabricating S
Calgary, Alberta 403-230-3705

C.W. Carry (1967) Ltd. P, S
Edmonton, Alberta 780-465-0381
www.cwcarry.com

Capital Steel Inc. S
Edmonton, Alberta 780-463-9177

Collins Industries Ltd. S
Edmonton, Alberta 780-440-1414
www.collins-industries-ltd.com

Empire Iron Works Ltd. [Edmonton] J, P, S
Edmonton, Alberta 780-447-4650
www.empireiron.com

Eskimo Steel Ltd. P, S
Sherwood Park, Alberta 780-417-9200
www.eskimosteel.com

GAR-DON Steel Industries Ltd. S
Nisku, Alberta 780-955-8034
www.gardon.ca

Garneau Manufacturing Inc. S
Morinville, Alberta 780-939-2129

Group Canam Inc.
Calgary, Alberta 403-252-7591
www.canam.ws

JV Driver Fabricators Inc. B, S
Nisku, Alberta 780-955-1746
www.jvdriver.com

Leder Steel Limited S
Acheson, Alberta 780-962-9040
www.ledersteel.com

Norfab Mfg (1993) Inc. B
Edmonton, Alberta 780-447-5454

Northern Weldarc Ltd. P, S
Sherwood Park, Alberta 780-467-1522
www.northern-weldarc.com

Omega Joists Inc. J
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www.omegajoists.com

Precision Steel & Manufacturing Ltd. S
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www.precisionsteel.ab.ca

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www.rampartsteel.com

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Spartan Steel S
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Supermétal Structures Inc., Western Division P, S
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www.supermetal.com

Supermétal Structures Inc., Western Division P, S
Leduc, Alberta 780-980-4830
www.supermetal.com

Supreme Steel Ltd. [Edmonton]
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www.supremesteel.com

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www.supremesteel.com

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www.trianglesteel.com

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www.tsesteel.com

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www.wfwelding.com

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www.waiward.com

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www.canam.ws

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www.ismbc.ca

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www.wesbridge.com

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www.russelmetals.com

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www.leroux-steel.com

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www.daleymetals.com

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www.devoecoatings.com
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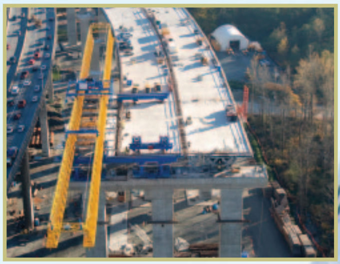

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