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NO 43 SUMMER 2012

On Fertile Ground

Steel fabrication in Saskatchewan's potash industry

+ Comparison of structural frame alternatives for office buildings using life cycle assessment methods

Understanding Steel Design, book review

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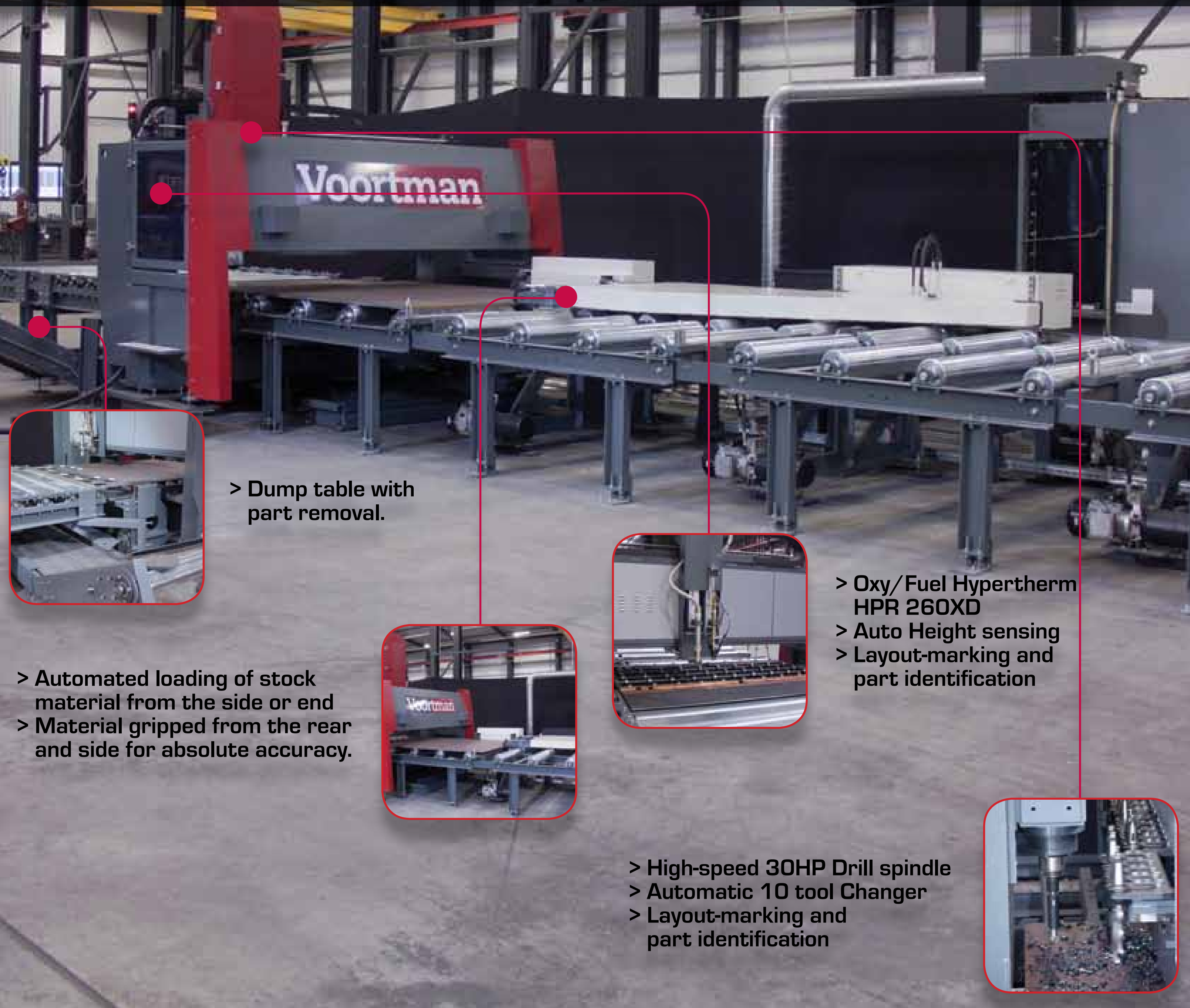

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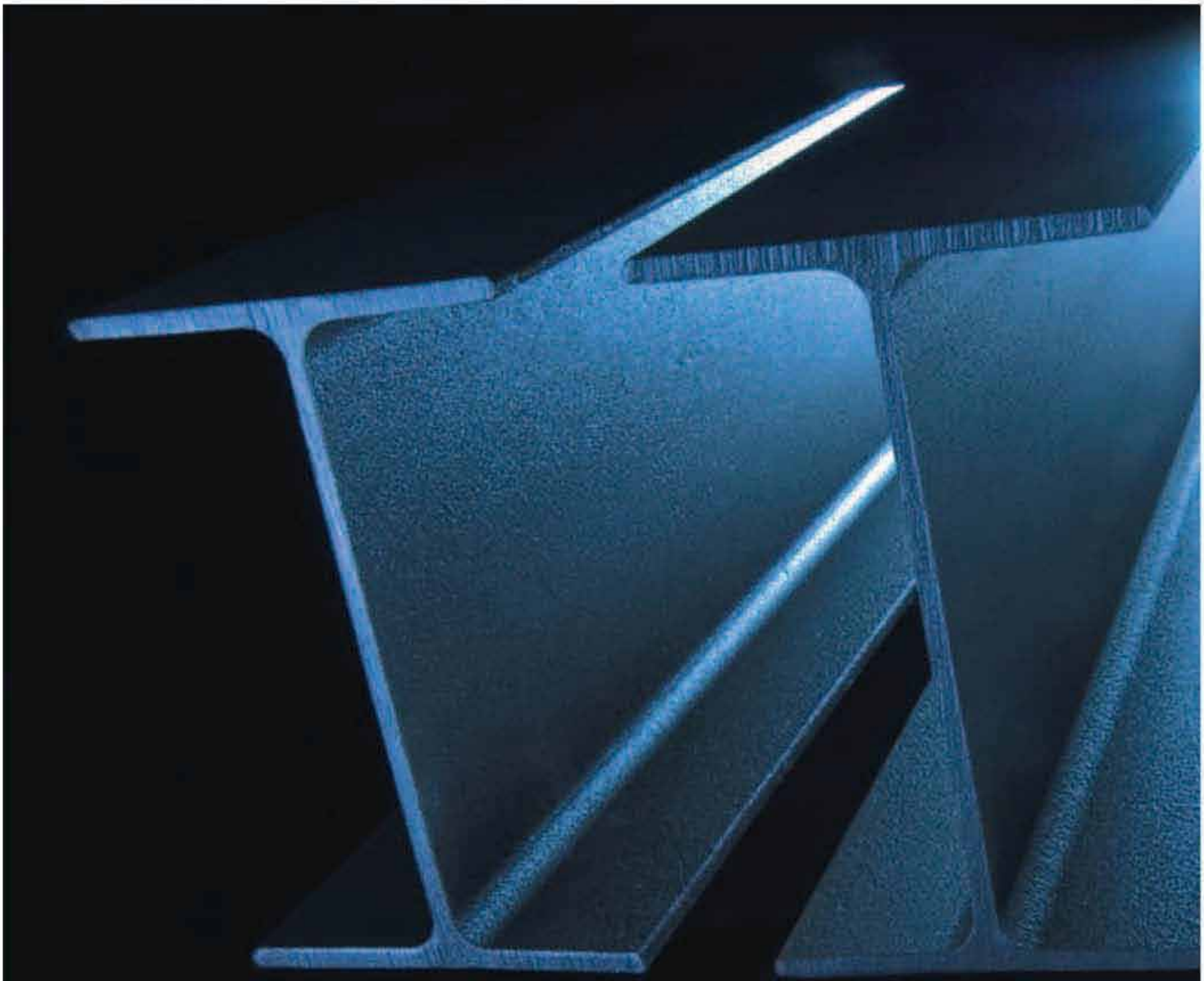

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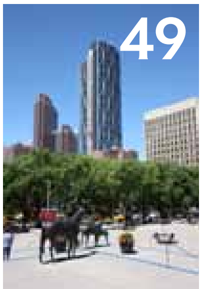

By Ed Whalen, P.Eng.

Pay me Please!

I always say that once you enter the steel business, chances are you'll never leave. It's like a one-way door. There's no going back. For you older folks, now is the time to start singing Hotel California.

Now, I am already hearing some of you wish that some of your competitors would leave. Yes, some of them may be putting in very low prices for reasons you don't understand. And yes, some of them may be putting in prices that they later don't understand. But in the end that is the challenge of estimating and, I would say, fun, risk and reward in this business.

The truth is we need our fellow competitors. We need healthy competition and we need our industry to collaborate, partner, improve, innovate and compete.

What we don't need is the fear and risk of not getting paid!

Whether you are a consultant, general contractor, fabricator, detailer or supplier, we all want to be paid and paid promptly. In this economy, it is ever so important that money moves through the economy quickly. The construction industry is one of the largest sectors in the Canadian economy. Expediting payment for services will help improve our Canadian economy, speed up the economic recovery process and, most importantly, put the money back where it belongs… with the company that did the work.

CISC, through the National Trade Contractors Coalition of Canada (NTCCC), has developed and proposed the following prompt payment legislation: *"An Act Respecting the Protection and Viability of Construction Contractors."* This proposed Bill would require the prompt payment by the owner and prompt payment down the entire chain to the end suppliers. Prompt payment legislation removes the ability to insert "paid when paid" and "paid if paid" verbiage from contracts. It also includes obligations to pay (monthly), terms on amount and approval of progress payments, rights to suspend work or terminate contract upon non-payment, and rights to information.

By the way, never ever, ever, ever, agree to and sign a "paid if paid" contract. You will have very limited recourse if you end up trying to litigate for reasons of non-payment. Never ever!

In an economy where banks are limiting lines of credit and quick to limit their risk, the concept of prompt payment is one of the most important items for the steel construction industry in 2012.

What is the real issue here driving this legislation? There are two main issues in question. The first is owners not having adequately secured funding for their project prior to the start of the project, which affects the entire construction team. The second is general contractors using the "paid if paid" or "paid when paid" clause to hold back subcontractors' progress draws to finance their own operations, which affects subcontractors and their suppliers. In short, some general contractors are taking on projects too large for the size of their companies and using trades' money to bankroll it.

Canada is lagging behind the rest of the developed world in implementing prompt payment legislation. Thirty-one states in the U.S., the U.K., Ireland, Australia, New Zealand and now the EU already have or have recently passed similar legislation. The results show that prompt payment has improved relations, reduced bank foreclosures and improved the strength of the entire local construction industry.

For a look at the draft legislation visit www.cisc-icca.ca/promptpayment.

During the summer when you meet with your local MP or MLA at their barbeque, make sure to let them know the importance of prompt payment legislation for your business and our industry.

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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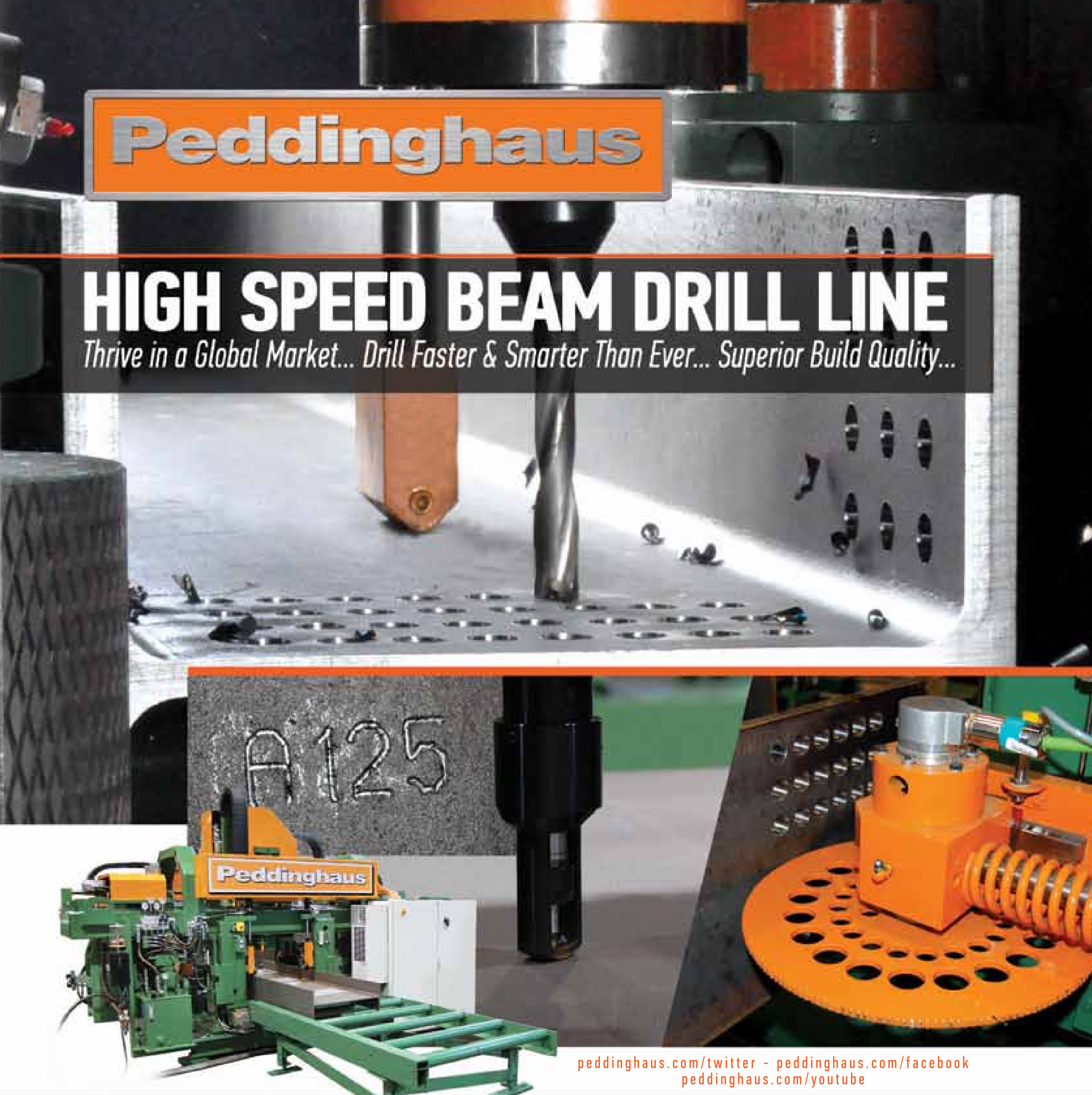
On the Cover: The Legends Centre, Oshawa, the 2006 Ontario Design Award, Architectural Award Winner. Image Courtesy of Richard Johnson Photography.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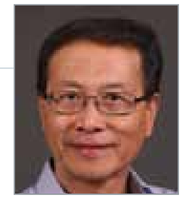

By Alfred F. Wong, P.Eng.

QUESTION 1: In the design of continuous beams and Gerber beams can I assume the inflection points laterally braced against lateral-torsional buckling?

ANSWER: One must not confuse the inflection points in the vertical bending moment diagram with the inflection points in the laterally buckled shape. In general, the buckled shape is not known at the design stage. Since the inflection points in the bending moment diagram generally do not coincide with those of the buckled shape they should not be taken as laterally braced unless they are braced.

QUESTION 2: I have used the effective-length method to design columns in sway-permitted frames as well as those in sway-prevented frames. But I cannot find the effective-length nomograph for sway-permitted frames in CSA Standard S16. Is the effective-length method still valid?

ANSWER: The effective column length method attempts to approximate the elastic critical column load for a regular frame that is without primary moments and consists of identical beams in each level and identical columns (see Figure 2). This idealized frame model does not account for any second-order effects in the beams at all. Moreover, in comparison with modern analysis methods that account for second-order effects etc., it usually fails to provide accurate results for real frames. Since the introduction of S16.1-M89, the Standard has abandoned the effective length

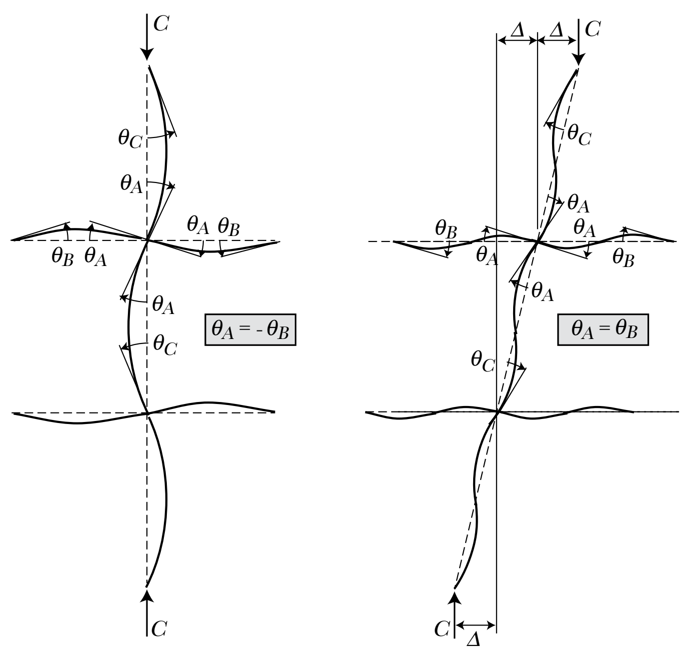

Figure 2. Effective column length method. Reprinted with permission from "Calcul des charpentes d'acier - Tome 1"

design method for sway-permitted frames. Accordingly, the nomograph for sway-permitted frames has since been excluded.

When an elastic analysis is used, the current standard, S16-09, requires the application of a second-order analysis that directly accounts for sway effects. Alternatively, P-delta effects are included using the amplification factor, U_2. In addition, notional loads are applied to account for the effects of partial yielding and initial out-of-plumbness.

Note: When P-delta effects and notional loads are accounted for, the use of an effective column length for sway-prevented case ($K \leq 1$) is permitted for consideration of lateral-torsional buckling. However, it is assumed in the effective length method that all members remain elastic prior to buckling. Hence the strong-column-weak-beam requirements for non-conventional construction, where applicable, may render its use inappropriate.

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.


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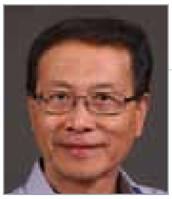

By Alfred F. Wong, P.Eng.

Multi-tier bracing panels within a storey

Figure 1a

The most common configuration of braced frames features a collection of single-bay planar braced frames that are typically vertical cantilever plane trusses having one panel in each storey. Each truss receives vertical and horizontal loads from the roof and floors while the roof and floor diaphragms laterally support the plane truss.

Figure 1b

In order to assure lateral support for the panel points of the truss chords, i.e., columns, the provisions for seismic design of moderately ductile and limited-ductility concentrically braced frames in CSA S16 have traditionally restricted their applications to braced frames having a single-tier panel per storey.

While most building braced frames comply with this configuration, frames that feature multi-tier bracing panels within a storey are not uncommon. A very tall storey often renders single-tier panel designs unsuitable or uneconomical because:

a) Very long braces are required; and
b) The panel's high aspect ratio dictates inefficient and/or impractical brace slopes.

Two examples of multi-tier panel braced frames are illustrated in Figure 1.

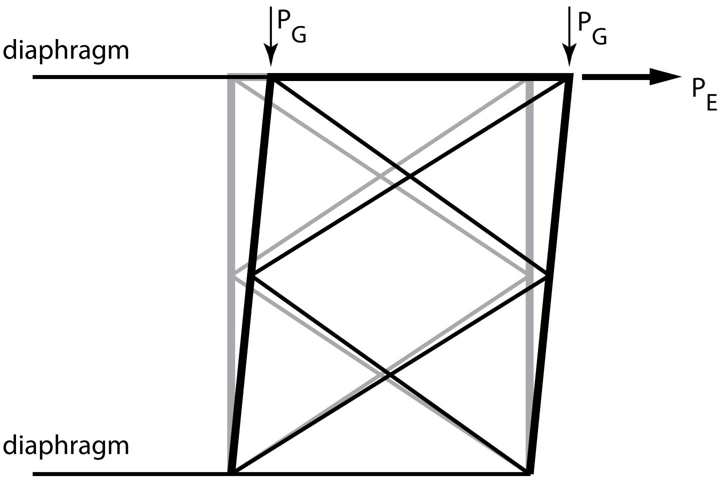

Figure 2. Elastic behaviour

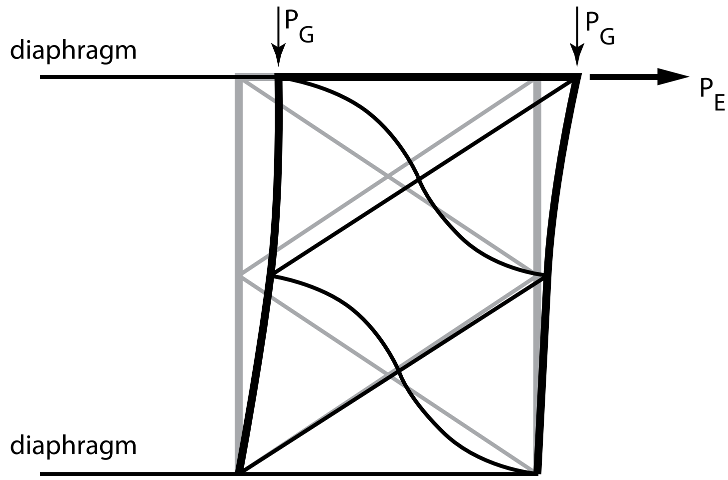

Figure 3. Column bending due to unbalanced brace forces

Elastic behaviour

Figure 2 shows schematically the elastic deformed shape of a single-storey frame with two-tier panels. This is how the frame behaves, provided that all components remain elastic when it is subjected to the full elastic seismic forces and the companion gravity loads. In this case, the horizontal strut that separates the panels is redundant.

Inelastic behaviour

Once a brace buckles, the column it intersects near mid-height will experience a relatively large unbalanced horizontal force (see Figure 3). The presence of a horizontal strut that is capable of resisting this force alleviates this impact (see Figure 4). Moreover, braces with in-plane gusset connections typically buckle out of plane and induce significant out-of-plane forces. An elastic analysis cannot capture the post-buckling behaviour and hence does not account for the above-mentioned in-plane and out-of-plane forces.

S16 provisions

Provisions for braced frames consisting of multi-tier panels have been introduced in *CSA S16-09*. Multi-tier

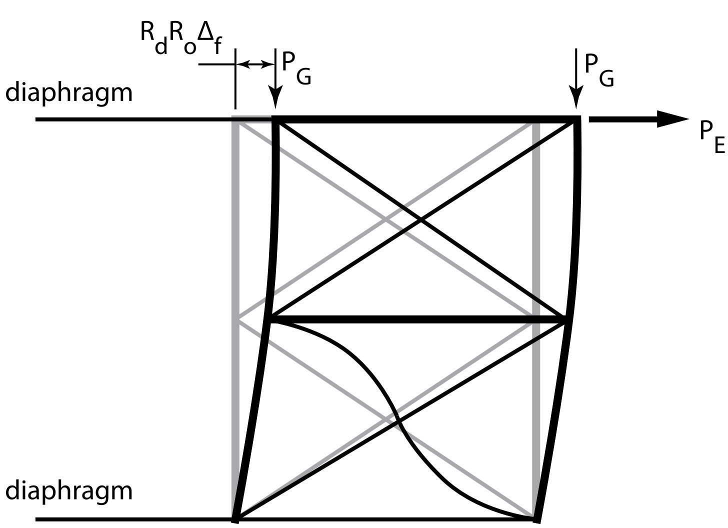

Figure 4. Nonlinear behaviour at design drift

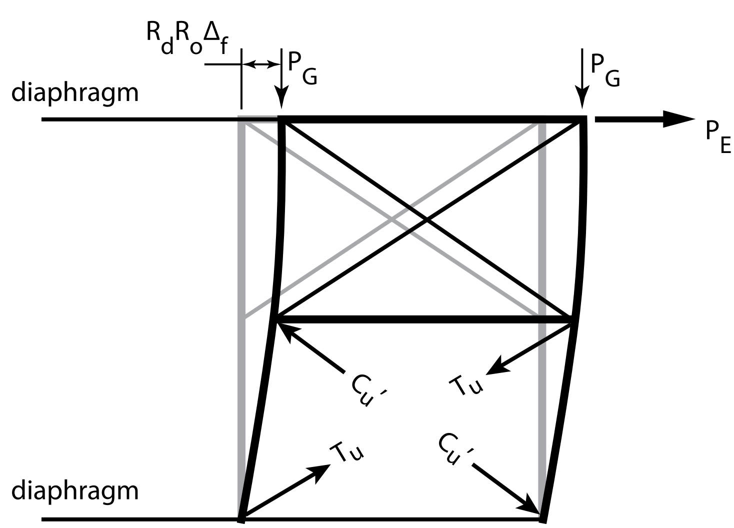

Figure 5. Permissible linear-elastic model

The strut(s) and columns must be capable of resisting the effect of all concurrent loads and load redistribution after brace buckling and yielding

X-bracing panels between horizontal diaphragms are permitted in limited-ductility braced frames provided they are proportioned in accordance with *Clause 27.6.6.* Specifically, the above-mentioned horizontal strut(s) must be provided.

In addition to all other pertinent requirements that apply to limited-ductility braced frames, the strut(s) and columns must be capable of resisting the effect of all concurrent loads and load redistribution after brace buckling and yielding. This inelastic behaviour may be modeled by means of a nonlinear incremental static analysis in which the horizontal load at the upper diaphragm level is increased stepwise until the lateral storey drift reaches the design drift, i.e., $R_d R_o$ times the elastic drift, while the companion gravity loads remain.

Alternatively, a linear elastic analysis may be used. In this elastic model the tension and compression braces in the panel where inelastic response is likely to initiate are replaced by forces representing their expected tensile resistance, T_u, and buckled resistance, C'_u, respectively (see Figure 5). The lateral load at the upper diaphragm level is increased until the design storey drift is reached. In the process, if the computed force in any compression brace in the other panels exceeds its probable resistance, C_u, the brace is replaced by end forces equal to its buckled strength, C'_u.

For either method, the concurrent loads acting on the columns must include an out-of-plane force at the panel points equal to 10 per cent of the compression force in the intersecting members.

Providing a more accurate picture

Comparison of structural frame alternatives for office buildings using life cycle assessment methods

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

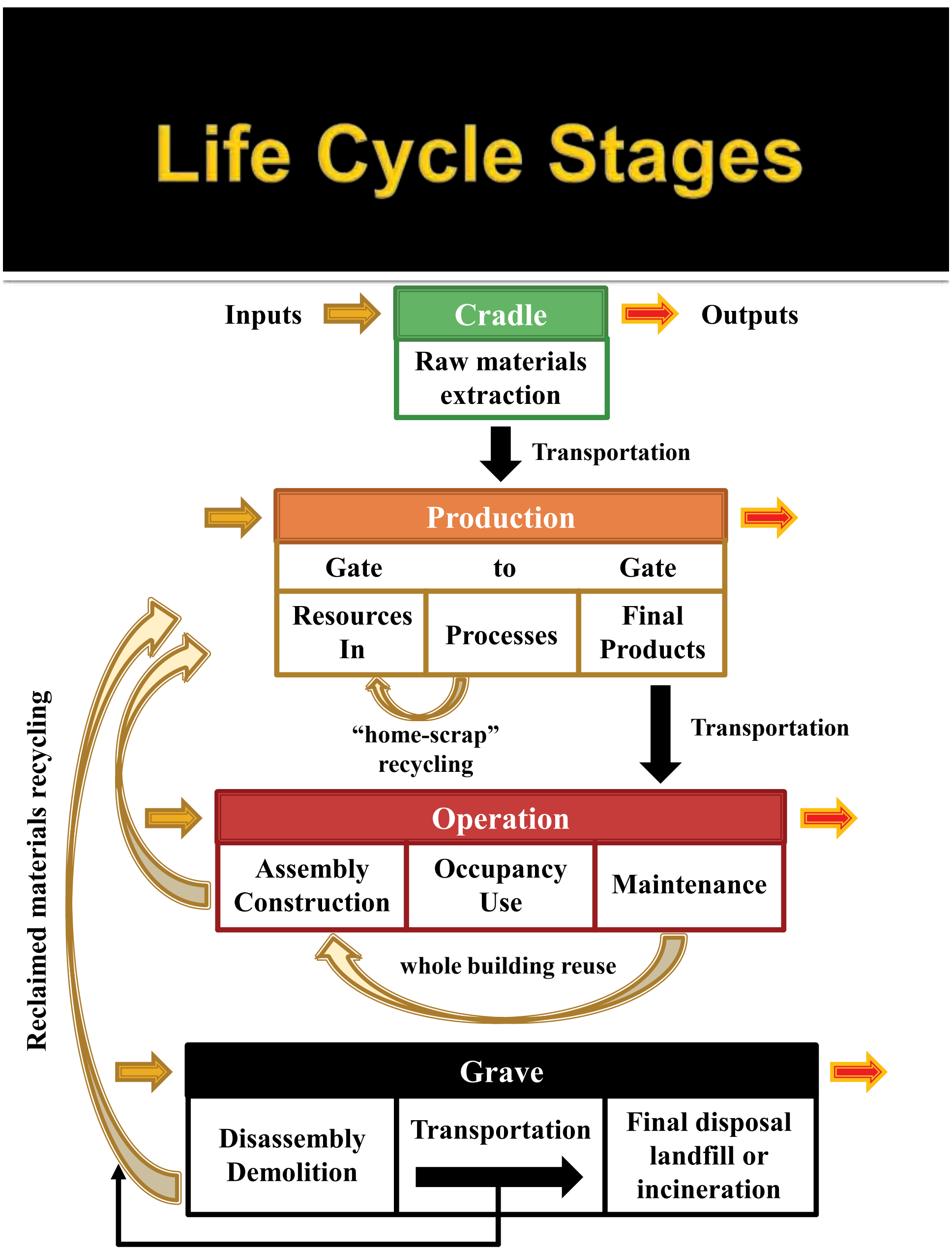

Figure 1 - Example of system boundaries for whole building life cycle

As the construction industry attempts to address the environmental impact of its activities, there has been a growing move to look beyond the impacts of buildings during their in-use phase (building operations) to consider a more comprehensive understanding of the life-cycle impacts, including the construction and end-of-life phases.

Life-cycle assessment (LCA) is a methodology, established by the International Organization of Standardization (ISO 14040), that aims to evaluate all environmental impacts cumulatively stage by stage over the entire lifespan of a product or process. It provides a more accurate picture of environmental trade-offs and avoids shifting environmental burdens between life-cycle stages.

LCA is useful for improving products and processes by identifying "greener" opportunities as measured over a full life-cycle, and therefore is a tool useful for decision makers. Furthermore, LCAs can help to change a company's mindset to more environmentally friendly aspirations. Figure 1 shows the typical life-cycle stages of whole buildings or components from "Cradle to Grave" or "Cradle to Cradle."

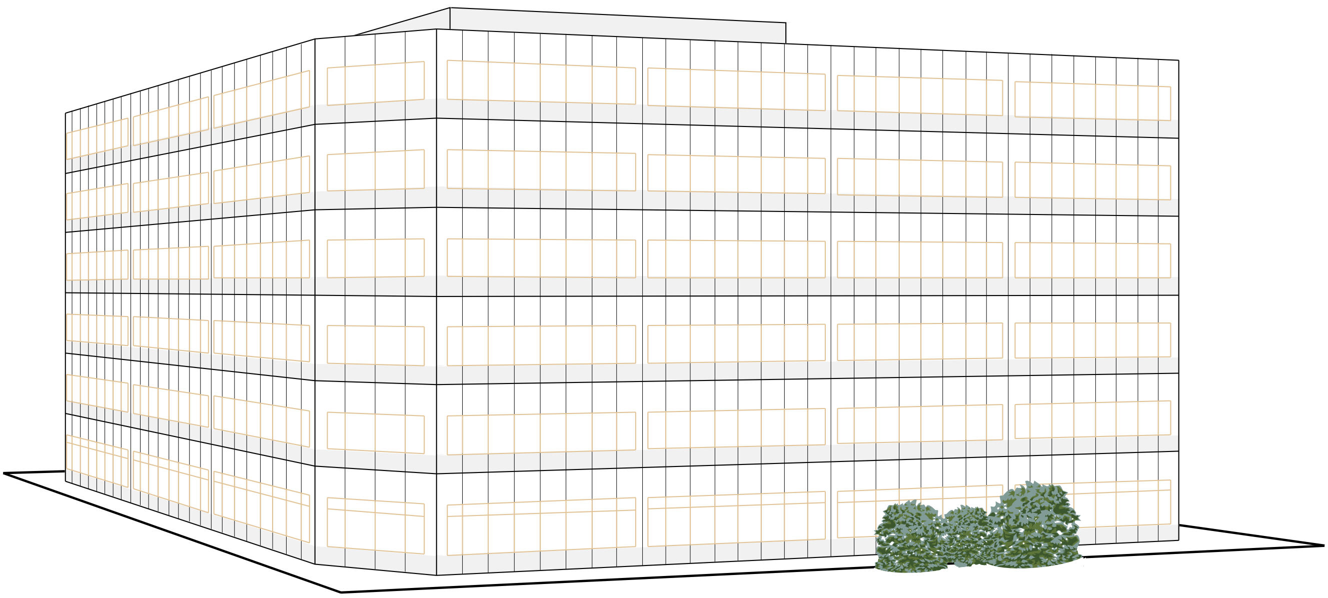

Figure 2 - Steel building 3d model (CISC, 2009)

A project at the Department of Architectural Science at Ryerson University used LCA methodologies to provide a scientific comparison of alternative construction options for a notional commercial building in Toronto. Since Athena Environmental Impact Estimator (EIE) is the most established and recognized building LCA software tool in North America, this study used Athena EIE software, but also considered alternatives.

The work predicted the life-cycle environmental impacts of constructing and operating a typical office building using steel-frame construction and comparing this to a concrete-frame alternative. The aim was to provide more reliable and consistent information on comparative environmental benefits of material and component selection putting the environmental impacts in a like-for-like analysis. The main focus was on global warming emissions (equivalent carbon dioxide emissions) and energy, although other environmental factors were also assessed.

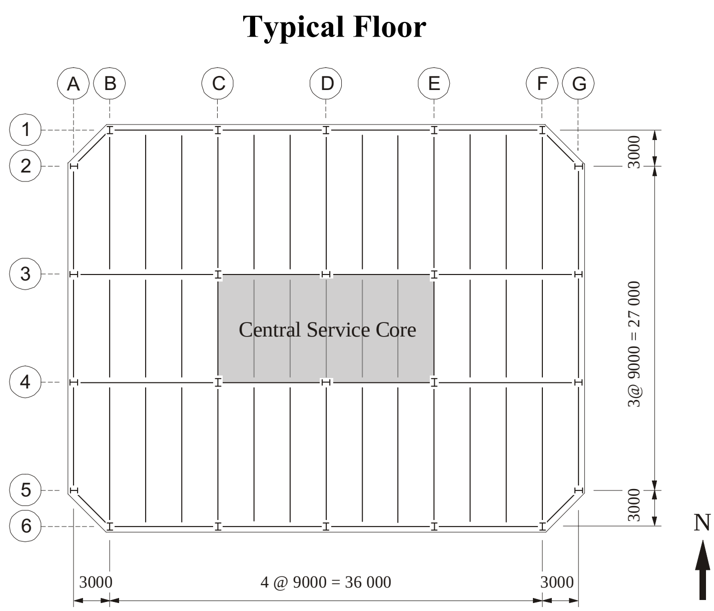

Figure 3 - Steel building, typical floor plan (CISC, 2009)

Study methodology

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-square-foot (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 with a concrete structure. 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.

The steel structure consists of 9m x 9m and 9m x 12m bays, with wide-flange columns and the braced frame central core of wide-flange columns with K bracing of hollow tubes. The non-composite floor system is a steel deck with concrete topping supported by wide-flange girders, beams and open-web steel joists (OWSJ). The roof system consists of steel deck (without concrete topping), supported mainly by 9m long OWSJs and 12m long girders. The concrete building consists of flat slab construction supported by columns. In this case, the structural grid was modified to 7.5m x 9m and 9m x 9m, in order to make it suitable for the flat slab construction. This solution has an increased number of columns, but is more appropriate for concrete structure. In both cases the building envelope consists of a curtain-wall with 70 per cent glazing area and 30 per cent insulated metal spandrel area (with 100mm batt insulation), and a conventional built-up roof and 200mm expanded polystyrene insulation. Interior walls and finishes consisted of 2x4 steel studs with ½" gypsum board.

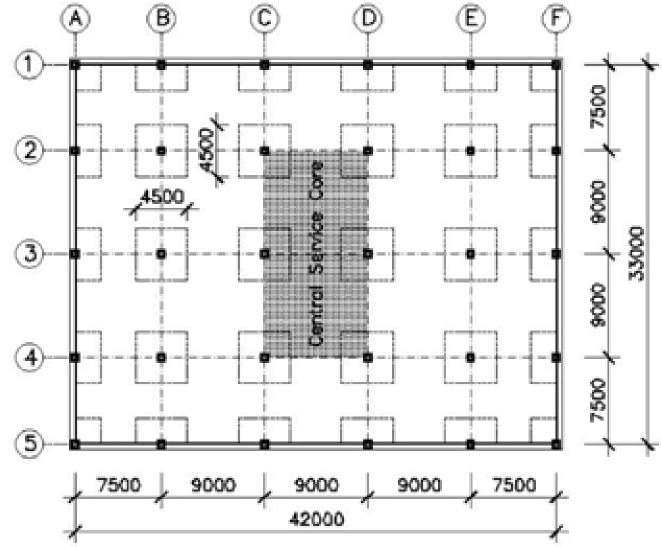

Figure 4 - Typical floor plan for the concrete building

Embodied impacts

The main results of the study provide a comparison between the steel and concrete building models. The focus is on embodied environmental impacts, which are the impacts occurring during extraction, manufacturing, transport, construction and end-of-life phases. Further analysis puts this in context of the impact from operating the building during its lifetime.

Figure 5 shows the standard Athena environmental impact categories along the X-axis. Under each category the performance of the concrete-frame building is set at 100 per cent and the proportional performance of the steel-frame building is shown. This indicates that the steel-frame building has generally lower impacts for most of the categories with the exception of Primary Energy Consumption (PEC), although in this case the difference shown is small (less than the 15 per cent margin of accuracy for Athena analysis).

Global Warming Potential (GWP) was chosen to develop a more in-depth comparison between the steel- and concrete-framed building models. It was found that the predicted impacts during manufacturing of materials are the dominant

elements of embodied GWP compared to construction or end-of-life issues. For the steel building, 94 per cent of the embodied GWP occurred during the manufacturing phase. For the concrete building, the equivalent figure is 91 per cent.

This suggests that using manufacturing processes with lower impact can be significant and dematerializing is a relevant strategy to reducing embodied GWP. Moreover, the results suggest that the construction and end-of-life GWP impacts for the concrete-framed buildings are more relevant than for the steel-framed buildings. This is due to the use of heavy machinery and varying techniques used for the two materials and end-of-life phases.

Transport of building materials is also a significant environmental factor. It was found that the predicted GWP from transportation for the concrete-framed building materials and components is higher than transportation in the steel-framed building. This difference is related to construction and end-of-life phases because Athena EIE considers more volume of materials are transported during construction of a concrete building and are also disposed at the end-of-life to land-filling. Steel products have a higher rate of recycling and reuse and lower weight decreasing transportation impacts.

When considering the GWP proportion of each assembly category as shown in Figure 6, floor structural systems seem to have the highest portion of GWP in both cases. It also appears that the columns, beams and floors carry more impact in concrete structures than in steel structures.

Embodied vs. operational impacts

The above analysis focuses only on embodied impacts and ignores the impacts from operating and maintaining the building during its in-use phase. To put the embodied component into context of its full life-cycle impact, the building models were evaluated over a 60-year life span to include operational energy use and recurring embodied impacts. The operational energy use was determined by using typical office energy use data from National Resources Canada statistics (NRCan, 2010), which estimate the average energy intensity of office buildings in Toronto to be approximately 420ekWh/m^2. Recurring embodied impacts are relative maintenance of interior finishing and envelope.

This analysis shows that predicted total embodied primary energy consumption (PEC) (which includes initial embodied and recurring embodied impacts) is on average only 2.1 per cent of the total lifetime PEC including operational energy. If we consider the embodied impact of only the structure, it is found to be only 1.1 per cent on average when compared to total lifetime PEC. For the total embodied GWP the proportion is on average 3.5 per cent overall and 1.8 per cent for the structure compared to total life-cycle GWP.

These figures are lower than some other studies which suggest that embodied impacts may typically be about 10 per cent of total impacts. However, for this study a long lifetime of 60 years was used, while other studies tend to choose lower lifetimes. Also, the operational energy use figures in the above calculation are based on averages for existing buildings, and may be lower for a building constructed to new codes.

In summary, LCA studies of whole buildings represent a very complex task that involves many challenges regarding definition of the system

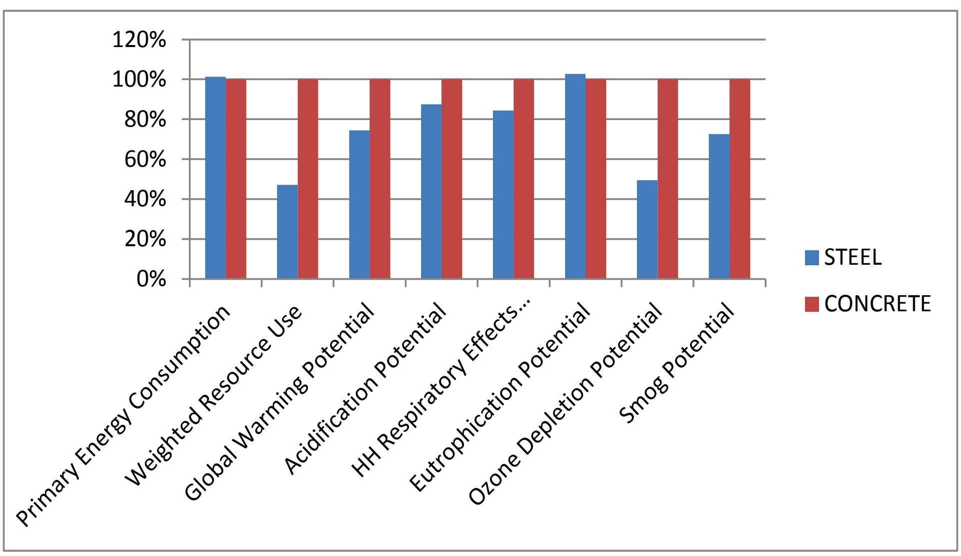

Figure 5 – Comparison of embodied impacts from EIE by quantities for the whole building models (relative to concrete model)

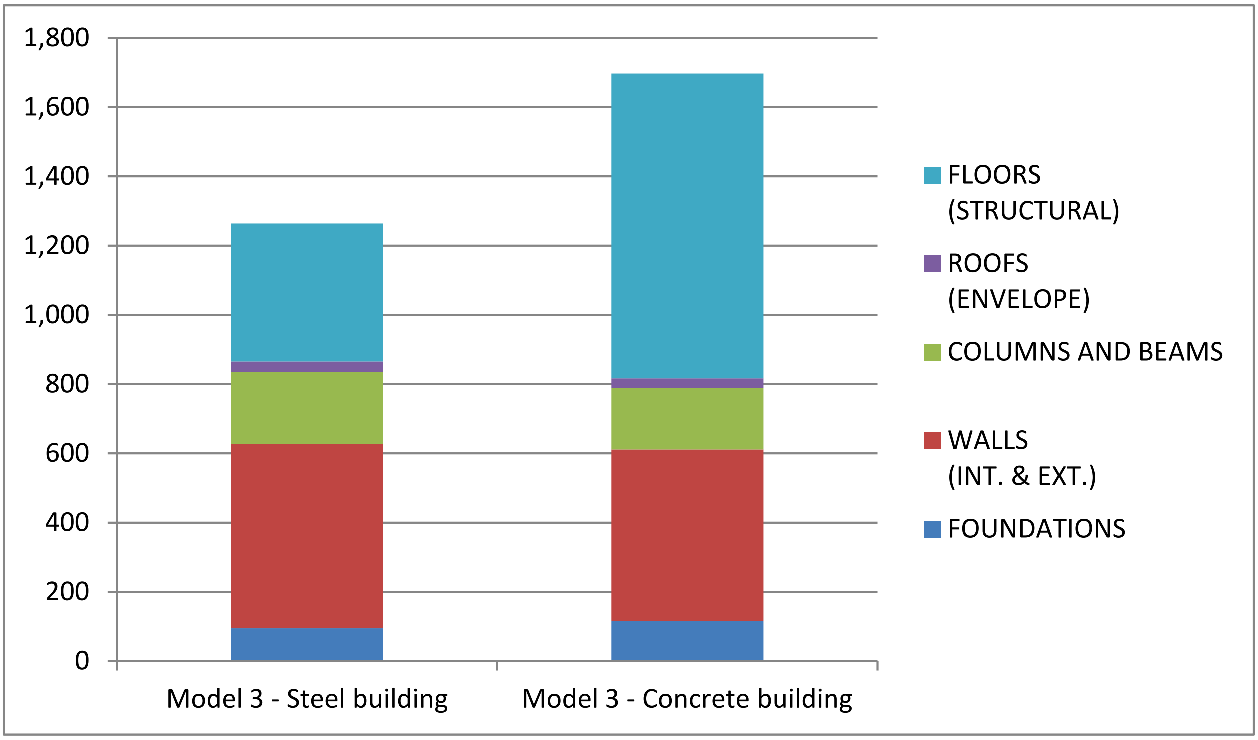

Figure 6 - Global Warming Potential proportion (in tonnes of CO2 eq) between assembly categories for whole building

boundaries, data collection and ensuring consistency in assumptions made over the long life of a building. LCA tools are perhaps more powerful as aids to design improvement of a particular building by selecting appropriate components rather than as a way of comparing a variety of buildings.

The accuracy of results in an LCA depends on the methodologies and LCI database. As long as they are used consistently, the results can provide fair comparison for the same building evaluated with alternative materials or assemblies. This, and other LCA studies, suggests little difference between overall life cycle impacts of steel and concrete buildings, and that it is still the operational energy use impacts that dominate.

This study was carried out by Ivan Pinto, MASc candidate, with supervision 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 http://www.arch.ryerson.ca/?page_id=366.

On fertile ground

Fabrication for Saskatchewan's booming potash industry can be a challenge – it's a matter of getting the details right

By Andrew Brooks

A 60-ton, 85-foot gallery section destined for Potash Corporation of Saskatchewan leaves Weldfab's shop prior to sandblasting and painting. ***Photo courtesy of Weldfab.***

One of Saskatchewan's unique advantages, globally as well as within the Canadian market, is the fact that the province lies atop vast quantities of potash, an essential ingredient in fertilizer that's in high demand around the world. Saskatchewan is the second largest source of potash in the world, possessing more than 40 per cent of the world's known reserves, and is home to a number of large potash producers, including Potash Corporation of Saskatchewan, the largest in the world.

Over the past several years, global demand for potash has steadily increased, and Saskatchewan's potash mining industry has expanded in response. This has generated a lot of work for steel fabricators, both in Canada and abroad, as existing facilities were expanded and new ones constructed. To take just one example, Agrium Inc. recently announced plans to invest $1.5 billion in enlarging its potash mining facility at Vanscoy in Saskatchewan. Another case in point: the recent decision of a German fertilizer company to invest $3.25 billion in building a potash mine from scratch.

"We've been working on potash mine expansions for about eight years now," says Rob McCammon, President of IWL

Supreme Steel did work for the massive, multi-year capacity expansion of the PCS Cory potash facility: projected to require 9,000 tons of steel, the project has absorbed over 20,000. *Photo courtesy of Supreme Steel.*

Steel Fabricators Ltd., a custom steel fabricator based in Saskatoon that does a lot of work for customers in the potash industry. "We've worked on just about all the expansions in potash mining here. We're quite diversified: a lot of fabricators are just about structural steel, or just about plate work, but we've been around long enough to have become skilled at a wide range of scopes of work."

One reason is that while it may be booming now, the Saskatchewan economy isn't large enough to offer fabricators the chance to become successful in a single, specialized line of work. "There's a lot of variation. We do get into the structural steel work, but also we do platforms, railings, walkways, and a lot of plate work," McCammon says. "It's a good way to train people up to a high skill level, but it also makes it easier to keep them around. There's enough variety in the work that they don't get bored."

JNE Welding, also based in Saskatoon, does fabrication for the mining, construction, petrochemical, power generation and transmission markets, and the potash industry provides many customers. Company President Jim Nowakowski says JNE works for different original equipment manufacturers (OEMs) who have the technical and sales staff to approach potash companies – or the EPCMs who represent them – to sell the kind of equipment used in processing potash.

"The OEMs don't usually have their own manufacturing facilities," Nowakowski says, "so they come to a custom fab such as ourselves to do that. We do a lot of work building process equipment – not the mechanical components with moving parts, but the flotation cells, the tanks, the pressure vessels, different types of processing tanks from different materials groups, alloys, stainless steels, carbon steels."

Corrosive conditions

The construction of components for use in potash mining, and especially for the refining process, does pose some unique challenges. While potash isn't corrosive in isolation, the refining of the raw ore, which involves the extraction of salt, creates extremely corrosive conditions.

"This is one of the most significant challenges with potash," Nowakowski says. "The design of the equipment is critical, as is the understanding of exactly what's required. In particular, the coating used to protect the fabrications is critical."

The corrosive atmosphere created by potash refining means that fabricators are required to apply a three-coat system to finished components, says Ross Fraser, Senior Vice President of Supreme Group and General Manager, Manitoba and Saskatchewan, for Supreme Steel. "The steel we fabricate is blasted to an SP 10 surface finish. The profile is a 3 mil [3/1000ths of an inch] jagged profile, and onto that you have to apply an 80 per cent solid zinc primer and two coats of epoxy."

The sharp edges created during fabrication must be eliminated, as a sharp edge won't take a coating properly. Accordingly, every edge has to be ground down to the primer and epoxy properly. "All pieces have to have a 1/16-inch radius ground on them," says Peter Davies, Owner/Director of Weldfab Ltd. in Saskatoon. "You have to run the grinder over every edge, which adds to the shop-hour labour cost." Among other things, it means a fabricator cannot quote a potash job the way they would quote a commercial job, he adds.

The brittleness of the fully cured coating also means extra care has to be taken during shop-floor handling and final shipment to ensure no chipping or scratching occurs. This means using fabric slings to hoist components, and inserting layers of dunning between them during shipment. It all adds to the time and cost of doing potash work properly.

The fabricator also has to be scrupulous about avoiding and cleaning up weld spatter. That's the kind of thing that may not matter as much in structural steel work, but the presence of weld spatter on a component that will be used as part of a potash refining process can easily promote the formation of corrosion cells by compromising the integrity of the coating.

Welding is another area where potash work poses unique challenges. Seal welding is mandatory throughout, a fact that isn't as widely understood as it should be. "A lot of people think that seal welding means dust-tight, and that's wrong," says Nowakowski. "It means that anywhere there's a seam, it has to be continuously welded. You can't have exposed stitch welding in potash work because it allows corrosion cells to get started."

If a job isn't properly seam welded, it is readily apparent when the steel arrives at the job site, and that's when the problem has to be corrected – by a local fabricator in cases where the job has been supplied by an out-of-province or overseas supplier. Nowakowksi recalls one case where bucket elevator sections arrived on site and immediately required some $90,000 worth of weld repairs. In another case, JNE was outbid on a job by a U.S. supplier, but Nowakowski and his team got some consolation when they were called in to redo some of the work later. "That was an education to both the EPCM on the job, and to the potash company," he says.

"In the wet areas of a potash mine or mill, you could almost class this stuff as an acid," says Davies. "In commercial work, an angle iron welded onto a beam can be stitch welded, and because it's going to be in a heated, enclosed environment, there would be no issues with it. In a potash environment there's no alternative. It has to be fully seal welded so no water or potash dust can settle into the openings and promote rust."

Quality assurance is an integral part of potash work, and Ross Fraser says he has found the CISC Quality System to be instrumental in securing potash customers. "Ensured quality through material tracking, traceability throughout the fabrication process and proper documentation: all these are mandatory for most potash-related projects." Fraser adds that most projects include third-party inspection, complete with backup documentation requirements.

The local advantage

Looking back at the beginnings of the Saskatchewan boom, Fraser says that the Supreme Group was in a fortunate position from the start. "We've done this type of work for 20-plus years, so when the expansion projects started taking off we had the experience, and because of Supreme Group's size and capabilities we were able to take on major projects."

The company became heavily involved with the Potash Corporation of Saskatchewan in 2003, and the work has steadily increased since then. Supreme doesn't shrink from making capital investments to boost its own capacity if work is anticipated: 20 years ago the company had around 24,000 square feet of shop space on a 10-acre site. Now, shop space totals over 55,000 square feet on 25 acres.

But the boom has brought in competitors who have been able to take advantage of the unique challenges of potash work by underbidding the experienced local fabricators who know that extra time, labour and cost are just part and parcel of doing the job right. The result, as you might expect, hasn't always been pretty.

"Those of us who fabricate pressure vessels are aware of the high-end requirements, so it's not a surprise to us," Nowakowski says. "But if it's, say, a bucket elevator casing, the people who manufacture those aren't always as diligent when it comes to looking at customer specs. They look at it as almost trivial. That's often where the greatest problems arise in a potash application. Some people just don't realize there's such a significant issue with corrosion and there's only a certain way it can be dealt with."

In this kind of a scenario, Nowakowski says, JNE Welding winds up trying to educate the customer, be it the EPCM, the OEM or even the potash company itself, "and at same time we look at whether we should be in that particular scope of work." It is easy to be underbid by a competitor who doesn't understand the particular challenges represented by potash, especially if that competitor is from far away and isn't likely to be around to face the repercussions if the job hasn't been done adequately.

"When the downturn hit in 2008 to 2009, a lot of fabricators came into the Saskatchewan market from elsewhere, and they got very aggressive with their pricing," Nowakowski says. "It really screwed up the market here for a couple of years. But over time, some of them have learned, others have been getting more work in their home markets so they've left, and some of that low pricing has gone away. At least it's not as ridiculous as it was."

Looking forward, McCammon sees a number of positive signs that job prospects are going to stay positive for the foreseeable future. Many Saskatchewan-raised tradespeople have returned home over the past few years, he says, a sign that the outlook is positive and also a possible buffer against a labour shortage. The increased work has helped fabricators develop their facilities, staffing levels, equipment and other systems, improving efficiencies and boosting their competitiveness. "We've added robotics and processing equipment in order to reduce the man-hours required to complete fabrication," says McCammon. And he appreciates what the CISC Saskatchewan Region has done to promote training in welding and fitting.

When it comes to potash work, Nowakowski believes the unique requirements of this kind of fabrication only reinforce the usual reasons why it makes sense to deal with experienced local firms. The local experience is just the first. The cost of shipping fabricated components to the job site is reduced, and of course the danger of damage to the brittle coatings in transit is also lower.

"When something goes wrong, we're close by to any potash mine in Saskatchewan. We can get there quickly, represent the OEM if need be, and take care of any issue that might arise from a fabrication perspective," says Nowakowski.

That would apply when it's somebody else's work that needs fixing too. It's been known to happen.

A Weldfab fume hood for pulp industry customer Tolko. Weldfab does more structural steel than platework, which IWL helps out on. *Photo courtesy of Weldfab.*


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Yas Marina Hotel, Abu Dhabi, UAE,
by Asymptote Architecture

Required reading: "Understanding Steel Design"

Terri Meyer Boake's book is a must-read not only for students, but practicing architects and engineers as well

By Loraine Fowlow, MRAIC

Written by Terri Meyer Boake, Associate Professor of Architecture at the University of Waterloo, with assistance from Technical Illustrator Vincent Hui, "Understanding Steel Design" is a welcome addition to the growing group of recent books aimed at teaching structures to architecture students.

Unlike its competitor titles, however, this book will also be of interest and use to the practicing architect and engineer because there is much technical information about steel processes and construction methods, including many details and connections. Answers to practical questions that most structural books omit, such as how and why was that built, are answered here. The author has an educator's eye for anticipating the type and amount of information that students and their instructors are looking for.

The approach that is taken in this book is certainly unique, with the author critically assessing what works and what doesn't in conventional textbooks on structural design for architects, and greatly improving upon the normative means of assembling and presenting this information.

Rather than presenting a survey of structural typologies with scantily illustrated examples, this book is based upon the author's direct experiences of some of the best examples of structural and architectural design in steel from around the world. Her position is that it is best that one views and understands building design through personal experience. The book's generous photographs, mostly taken by the author herself, attest to this firsthand observation and provide an understanding of how and why steel buildings go together.

The second innovation in the approach taken in this book is the clever Process Profiles that illustrate and explain the examples of the topics covered. More than the normative case study approach, these comprehensively documented examples illustrate in a detailed fashion the design and detailing of steel buildings, complete with multiple photos and graphics of connections, as well as fabrication and construction methods and processes. More than providing just one or two "beauty" shots of buildings, as is the case in most architecture books and journals, we see close-ups of details, connections, and fabrication and construction processes that are exceptionally useful. For the architect and architecture student in particular, these examples and images provide insight into steel fabrication and detailing previously only in the domain of the engineer. But, as the author points out, this is also a realm that is of increasing interest and use to architects, given the rapid use and development of exposed steel systems.

Reichstag, Berlin, Germany
by Foster + Partners

The Process Profiles include many excellent, recent examples of steel design, such as the Chin Crystal at the Royal Ontario Museum (Studio Daniel Libeskind); the Leslie Dan building at the University of Toronto (Foster + Partners); the addition to the Art Gallery of Ontario (Frank Gehry); and the Bow Tower in Calgary (Foster + Partners/ Zeidler Partnership).

In addition to the projects included in the Process Profiles, there are numerous other well-illustrated examples, such as the Beijing National Stadium, Capital Gate in Dubai, Swiss Re in London, the National Grand Theater of China in Beijing, the Experience Music Project in Seattle, and many more than what can be mentioned here.

Wide scope

The scope of the book covers an enormous amount of ground, packaged into a relatively concise 240 pages, many of which are heavily illustrated with photos and graphic explanations. The book's first two chapters begin with a historical overview of the nature and importance of steel itself within the contemporary building industry, explaining both the structural fundamentals of steel ("steel is about tension") and contemporary milling and fabrication techniques.

Professor Meyer Boake's long affiliation with the Canadian Institute of Steel Construction (CISC) is evident here. The basics of the steel industry are presented and accompanied by useful photographs taken by the author within steel fabrication plants, and steel properties and common shapes, detailing and specs, and design software are also covered. This is worth mentioning, as this chapter alone is unique among books of a similar nature. The actual making of steel is rarely mentioned in structural books, let alone explained and illustrated, and will be of particular interest and use to students of both architecture and engineering.

Pudong Airport Terminal 2, Shanghai, China

The book then follows a logical development of topic areas: connections and framing; fabrication, erection and design; AESS history, design and detailing; coatings and fire protection; curved steel; advanced framing systems (diagrids); castings; tension systems and spaceframes; glazing systems; and advanced framing systems (steel and timber). The book concludes with a chapter on steel and sustainability, which is a useful yet often overlooked topic of interest, and finally, with steel in temporary exhibition buildings, of interest to students for whom these well-publicized structures are often a first introduction to designing in steel.

As an instructor of structures for architects for over fifteen years, and the purveyor of virtually all of the books on the market for teaching the subject, my personal appreciation is for the chapters that cover areas of interest to my students that are not available in other books. In particular, the chapters on curved steel (Frank Gehry: how does he do it?), coatings/fire protection, castings, glazing systems, and steel/timber systems will be gratefully consumed by students. As architectural design utilizing steel as a primary structural and envelope material has developed over the last 10 to 15 years, architecture students continue to conceptually design structures that defy gravity and determinate calculations. This book will greatly assist with teaching them how to do this in an approachable, instructive and interesting fashion.

This book assembles topics and areas of interest related to steel design and construction in one accessible volume, which will be welcomed by students, instructors and practitioners alike. Previously, this information was only available through piecemeal sources of various books and Internet sites. In addition to the sheer wealth of information presented, both textual and graphic, it is Professor Meyer Boake's educator's eye that lifts this book above its predecessors and competitors. Because of its wonderfully useful scope and innovative approach, this book is certain to be at the top of the required reading list for structures courses across North America, and should be on every architect's and structural engineer's bookshelf.

"Understanding Steel Design," Terri Meyer Boake, with Vincent Hui, Technical Illustrator, Birkhauser (240 pgs; photos, ills.)

Loraine Fowlow, MRAIC, is Associate Professor of Architecture, University of Calgary and is also on the Board of Governors, Steel Structures Education Foundation.

Sustainable Technologies Addition, Skills Training Centre, Durham College Whitby Campus
Photo courtesy of Barry-Bryan Associates Limited

Architectural and structural steel in Durham Region

A look at how one company effectively utilizes steel structure in various building types in southern Ontario

By Dennis L. Bryan, P. Eng.

Steel has long been a construction material of choice for local Durham Region project designs by Barry-Bryan Associates (1991) Limited (BBA), Architects, Engineers, Landscape Architect, Project Managers, working out of their Whitby, Ontario office.

BBA's designs have utilized steel structure in a number of ways for a variety of building types. They have used steel effectively, alone and in hybrid constructions with other building materials to create both playful and dramatic spaces.

"A number of our recent green field builds utilized typical low rise structural steel frame construction. Several of these projects were fast track projects and we were able to rely on structural steel supply, fabrication, delivery, and erection times," says Denny Bryan, President of BBA.

The use and finish of the steel framing varies from project to project. In some cases, the steel frames have been encased in fireproofing and suspended ceilings. In other cases, BBA has been able to use the expressiveness of exposed structural steel to contribute to the design and feel of the finished space.

Mackie Harley-Davidson, Oshawa
Photo courtesy of Richard Johnson Photography Inc.

Customer Service Atrium, Ajax Town Hall
Photo courtesy of Richard Johnson Photography Inc.

This approach was particularly effective in the Mackie Harley-Davidson Buell motorcycle dealership in Oshawa where exposed steel contributed to the openness of the bike display and sales areas. Steel design offered large open glazed spans to showcase motorcycles to the public passing by this dealership. This project was the recipient of the Harley-Davidson dealership annual design award.

Similarly, structural steel was selected to express a special display space for the OWASCO RV Sales Centre in Whitby. Structural steel framing was used to create long spans and high building ceilings for the RV Sales Centre. The building architecture called for angled walls, which were fully glazed to create the "RV in the Box" building display. This building provides excellent sales exposure to Highway 401 in Whitby.

Structural steel has played a significant part in the development of Durham College's Skills Training Centre at the Whitby Campus. BBA has been involved in many phases of the design of the Whitby Campus since its inception in 1992.

Initial phases utilized composite steel construction, which provided minimum structural depth to allow new second floor class rooms to be constructed in available building vertical space.

Subsequent phases of design and construction were implemented using fast-track construction techniques, including pre-tender of the structural framing system for a single storey academic wing addition. This strategy allowed foundations to be built in the fall and steel erection to be completed throughout the winter months. The steel frame was designed to allow a future second storey, which came to fruition in 2008.

The Sustainable Technologies Program required new second storey academic lab and office space designed to meet LEED certification standards. Extensions of existing first floor columns and reinforcement of adjoining steel beams and

Projects

Examples of low-rise steel framed building projects designed by BBA in the Region of Durham include:

- Campus Ice Centre (twin pad arena), Durham College/ University of Ontario Institute of Technology
- Recreation and Wellness Centre (triple gymnasium/fitness centre), Durham College/ University of Ontario Institute of Technology
- Whitby Community Office, Durham Regional Police Service, Regional Municipality of Durham
- Commercial Office Expansion, 250 Water Street, Whitby
- Legends Centre, Multi-purpose Recreation Centre, Oshawa (winner of CISC Steel Award)
- Bob Myers Chevrolet/GMC Dealership Expansion, Ajax
- Town Hall Redevelopment, Town of Ajax
- Anne Ottenbrite Pool Expansion, Town of Whitby;
- Taunton Medical Building, Oshawa, Ontario (Currently under construction)
- Port Perry Medical Building, Port Perry, Ontario (Currently under construction)
- New Council Chambers, City Hall, City of Oshawa
- Classrooms, Office, and High Bay Shop Expansion, Skills Training Centre, Whitby Campus, Durham College
- Sustainable Technologies Expansion, Skills Training Centre, Whitby Campus, Durham College
- New Addition and Renovations, New Oshawa Campus, Trent University
- New Front Entrance, Darlington Sports Centre, Municipality of Clarington
- Bowmanville Indoor Soccer Facility, Municipality of Clarington

open web joist framing was completed on the existing structural steel system.

The steel roof framing provided excellent flexibility for the required wind turbine and photovoltaic panel installation. The addition of the wind turbines was a design change during the late stages of the final design. This change was readily accommodated with design, fabrication and installation of additional structural steel. Erection of the structural steel over the existing classroom space was readily accommodated in phases while other areas of the building were occupied.

Renovation use

The use of structural steel framing has also proven beneficial in the recent renovation of the industrial building housing BBA's offices on Water Street in Whitby.

OWASCO RV Sales Centre, Whitby
Photo courtesy of Richard Johnson Photography Inc.

The developer needed a lightweight and readily adaptable structural framing system to construct a second floor inside of the existing warehouse space. Existing caisson foundations capacities were limited, requiring a revised column layout to allow insertion of a new column line to support the existing steel truss roof framing. This approach relieved existing column caisson loading, making it possible for existing columns and foundations to support the new second floor loads. Steel framing modifications to existing steel trusses were easily accommodated.

The use of structural steel allowed equipment access and erection of steel within the existing building envelope with lighter lift equipment. Additionally, the steel of the main entry canopy and rear deck was left exposed to direct roof rainwater into a fountain system with water flows on "canals, aqua ducts, and steel 'boats' floating on air."

The Ajax Town Hall redevelopment utilizes structural steel framing to create localized additions and connections between existing buildings to establish a new Town Hall plan. Exposed steel in the main customer service lobby allowed BBA to support the new building addition, while at the same time expressing the H.M.S. Ajax ship architecture of the new Town Hall. The new steel framing was easily erected in the restricted construction site.

BBA has chosen structural steel for the above projects based on a variety of design and construction considerations including:

- Lighter weight of steel construction compared to other available systems;
- Future adaptability for expansion or changes in design loads;
- Availability of quality supply and fabrication and erection trades;
- 'Fast-track' advantages to structural steel pre-tender and accelerated project schedules;
- Steel construction capability through all seasons of the year;
- Relatively smaller structural sizes to suit floor plan layouts and to optimize room sizes;
- Compatibility with other building materials;
- Lateral resistance without need of shear walls;
- Structural design versatility;
- Architectural expression through the steel construction; and
- Adaptability to a variety of finishes.

BBA continues to utilize structural steel in projects across the province of Ontario. They are looking forward to new design possibilities and new ways to incorporate steel construction in future projects.

Dennis L. Bryan, P. Eng., OAA, MRAIC, CAHP, is President of Barry-Bryan Associates (1991) Limited.

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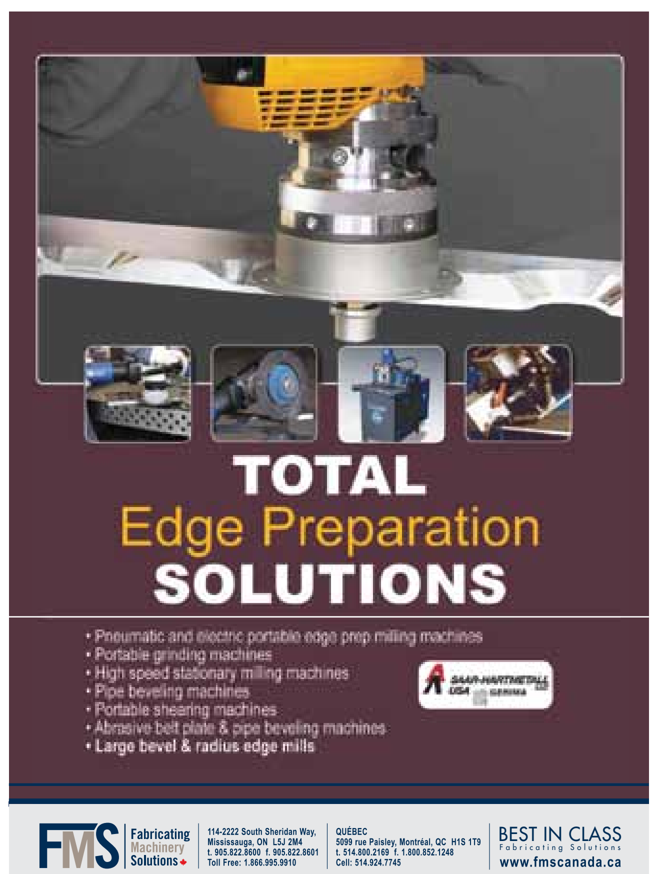

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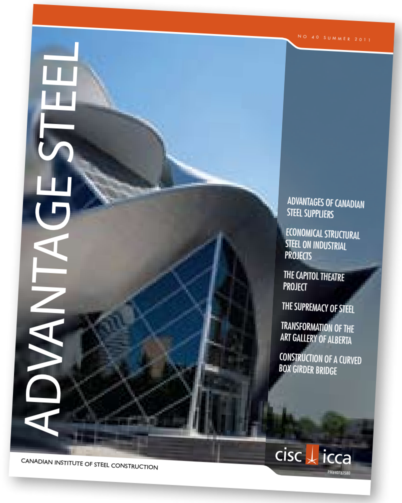

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Photo courtesy of Stéphane Brügger

A new home, at last

Orchestre symphonique de Montréal inaugurates its modern new concert hall, built to exacting standards

By François Picher, Eng., M.A. Sc.

On September 7, 2011, the Orchestre symphonique de Montréal (OSM) inaugurated its new concert hall, meeting the highest standards of acoustics, stage design and architecture.

The Maison symphonique de Montréal holds an audience of up to 2,100 and is part of the Place des Arts complex in Montréal. This new concert hall can be accessed directly from the Place des Arts complex, with its five existing performance spaces, and gives the city additional cultural infrastructure of international calibre. Along with the concert hall itself, the project includes three levels of underground parking, an integrated unloading bay and public meeting spaces.

The project was developed as part of a public-private partnership with the Government of Quebec, which defined the design parameters and acoustic requirements for the concert hall with the help of Artec, a New York firm that has worked on other renowned concert halls and is widely recognized for its design expertise.

The objective was to give the Orchestre symphonique de Montréal a permanent home that met its acoustic requirements. The firm chosen to carry out the project would not only undertake the design and construction, but also be responsible for maintenance and financing for a 30-year term. Three teams vied for the project, each one having to develop a concept jointly with the client.

In March 2009, at the end of this nine-month development period, SNC-Lavalin finally secured the mandate to proceed. The concept selected was the result of close collaboration between acoustics and stage design specialists and the project architects and engineers, who worked tirelessly to achieve the world-class acoustic targets specified by the client.

Winch and cable system

Steel framework view of the concert hall

Maison symphonique de Montréal

Work began: May 2009
Work ended: September 2011
850 tonnes of structural steel

OWNER: Ministère de la Culture, des Communications et de la Condition Féminine (MCCCF)
DEVELOPER: Groupe immobilier Ovation
ARCHITECTURE AND DESIGN: Consortium Diamond and Schmitt/AEdifica
GENERAL CONTRACTING: SNC-Lavalin Construction
STRUCTURAL ENGINEERING: SNC-Lavalin Inc.
MANUFACTURING AND DETAILING, CISC MEMBER: Canam Group

The whole project, including detailed design and construction, was completed in less than 30 months.

Soundproofing the auditorium

The site chosen by the client for the Maison symphonique de Montréal posed a number of problems. In particular, because of existing structures the new concert hall had to be built above an underground parking lot. In addition, a subway line runs below the northern part of the site. This infrastructure emits vibrations that could have permeated the concert hall structure.

A variety of solutions was therefore required to meet the acoustic quality criteria for the concert hall. In terms of structure, the guiding principle was to ensure total separation of the auditorium from adjacent structures, both vertically and horizontally.

The acoustic enclosure is 65 metres long, 35 metres wide and 28 metres high. It is bounded by three thicknesses of masonry wall, assuring soundproofing from external noise. This soundproof volume rests on more than 175 rubber pads lined with steel plates, to prevent the transmission of vibrations from the support structures and an adjacent underground parking lot.

The form and texture of the wood surfaces inside the performance space are designed to optimize the sound of musical instruments. All interior surfaces of the walls and balcony parapets are curved and coated in wood veneer. In addition, mobile panels on the ceiling and suspended from the roof structure are designed to modulate the volume in the hall to suit the type of event taking place. These mobile panels can be lowered or raised to optimize and adjust the acoustic properties of the hall.

Use of steel

The upper portion of the auditorium features a steel beam resting on the balcony slabs more than 20 metres above the main floor. Steel columns with a clear height of 10 metres support the roof, which is composed of louvered trusses three metres deep.

Using steel for the framework made it possible to integrate a technical space into the structure to house the whole complex system of cables, pulleys and winches used to adjust the mobile ceiling panels. The space between the upper and lower chords of the three-metre-deep louvered trusses was used for the installation of these systems.

To ensure the auditorium is soundproof, the lower portion of the steel trusses supports a slab 190 mm thick that serves as the floor of the mechanical room in the roof structure. The upper portion of the steel trusses supports a 250 mm slab, as well as an additional cover layer 150 mm thick. The steel trusses had to be designed to accommodate these heavy permanent loads.

Using an integrated 3D model proved essential to ensure all the necessary coordination between the steel framework components and the systems of cables and winches for scenery components and other mechanical systems. The exact location of the truss diagonals had to be adjusted to accommodate the cables running through them, whose positioning was constantly reviewed, based on acoustic and stage design criteria as well as changes in the architectural plans.

Because of the loads from the winches and pulleys controlling the mobile ceiling panels, secondary structural elements had to be used for load transfer to the main structure. All pulleys and winches were anchored to the steel framework with specially designed steel elements. More than 350 members, positioned to precisely match the winch and pulley system requirements, were fixed to the roof truss panel points.

The building's external shape reflects the curving geometry of the acoustic enclosure. The 10-metre steel columns were used as the base for the roofs of the concert hall's side balconies. These roofs, in turn, cantilevered by up to 4.5 metres, form the base for the lintels on which the curved exterior masonry walls rest. In many cases, these permanent loads are more than a metre from the column axes, causing considerable eccentric loading. Steel columns 600 mm deep had to be used to support these loads.

Steel framework was a wise choice for this type of architectural style. With its ability to conform to the curves of the exterior masonry facade, steel was ideal for the conditions under which this project was executed.

Lateral stability

It was quite a challenge to guarantee the stability of the auditorium structure, which was separated from the support structure and supported by rubber isolators, while limiting the movement caused by lateral loads.

A system of steel stops was designed for placement underneath the auditorium structure, at the level of the isolators. These stops are positioned in strategic locations beneath the structure's base, and equipped with pre-compressed isolators that limit displacement of the base while maintaining the integrity of the structure's acoustic soundproofing.

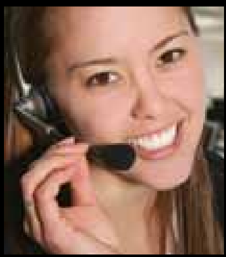
To limit any differential displacements between the separate acoustic enclosure and adjacent structures, the structure of the auditorium roof is also fitted with a system of steel stops. At each end of the acoustic enclosure, this stop system ensures lateral loads are transferred to the load- bearing walls, assuring the lateral stability of the structures adjacent to the isolated structure.

Pre-compressed isolators are used so that lateral differential movements between the acoustic enclosure and the adjacent structures are limited, both lengthwise and crosswise.

Overall, the client-imposed requirements for the acoustics of the Maison symphonique de Montréal made this project unique. The technical challenges of these restrictions led to original solutions being put in place within a very tight construction deadline.

Beyond the technical challenges of building this venue, the project's true success lies in the way this concert hall is raising Montreal's profile as a centre for the arts.

François Picher, Eng., M.A. Sc., is Project Manager and Engineering Design Officer at SNC-Lavalin



The Bow: Fire protection of a diagrid structure

Determining fire safety for Canada's first building to include a curved diagonal grid structural steel frame

By Jon Winton, B.Tech., & John Roberts, P.Eng.

The Bow is a 58-storey office tower in Calgary, Alberta, and the fifth tallest building in Canada. It is the first building in Canada to incorporate a curved diagonal grid (diagrid) structural steel frame. The floor plan shape resembles a quarter moon with the concave elevation fronting four vertically stacked atria ranging in height from five to 23 storeys.

Diagrid structures offer economical structural strength and stiffness to resist both vertical and horizontal building loads, and increased interior design freedom for interior spaces by concentrating a majority of columns at the building perimeter.

In addition to the obvious geometrical design and fabrication challenges, fire protection of this large steel structure also represented a significant undertaking. One desirable aspect of diagrid framing is the bold aesthetics of the exposed diamond pattern created by intersecting diagonal steel columns. The Alberta Building Code required the Bow's structural frame to have a two-hour fire-resistance rating, equivalent to that of the supported floors. Exposed steel does not have significant inherent fire resistance such that additional fire protection was required.

Fire resistance of steel

The triangular-shaped columns were of a unique geometry and large dimension that were not represented in directories of fire-tested and listed assemblies. Full-scale fire-testing was conducted to ascertain an acceptable method of fire protecting the diagrid columns while expressing their dynamic character.

Intumescent coatings were selected due to their application as thin films presenting smooth paint-like finishes revealing the intrinsic steel structure. Intumescent fire protection expands when heated to create an insulating char slowing the rate of heat transfer to the underlying steel. Steel strength reduces as temperature increases.

In general, steel retains strength and stiffness approximately equal to 50 per cent of its strength and stiffness at ambient conditions at a temperature of 600°C. This is the reduced strength at which steel structures are generally considered susceptible to permanent deformation and structural failure under normal loading.

Steel's high thermal conductivity and high heat capacity make it an effective heat sink. A steel section's fire performance is dependent on its M/D ratio, which is a ratio of its mass (M, in kg/m) and heated perimeter of the inside surface of the fire protection (D, in metres). A compact section with a high M/D ratio has a large mass to distribute and store heat, and a low heated perimeter or surface area through which to absorb heat.

A section with low M/D ratio conversely has comparatively limited mass to store heat and a large heated perimeter

Post-fire test column being removed from furnace

to absorb heat such that the rise in steel temperature, and resulting loss of strength, occurs more rapidly than in a section with higher M/D ratio. A high M/D ratio is indicative that less externally applied fire protection material is required to a steel section to achieve a particular level of fire resistance, as compared to a section with a lower M/D ratio.

The Bow diagrid is composed of steel members of varying dimension and mass. A 1 m length of the largest member of the Bow diagrid has a mass of 2,802 kg/m or the approximate equivalent of two compact automobiles. This large mass, and an M/D ratio of 746, dwarf the characteristics of standard steel section shapes commonly used in steel building structures and referenced in fire resistance directories. The large M/D ratio indicated that less external fire protection material may be required to achieve the required two-hour fire-resistance rating, than indicated in fire resistance directories. Use of less fire protection material would be more economical and environmentally conscientious.

Bow diagrid fire testing

The triangular sections of the diagrid columns have large, flat surfaces and acute corner angles. There was concern for delamination of fire protection from the large flat surfaces and high steel temperatures near the acute corners contributing to steel failure. Full-scale testing was conducted by three fire protection manufacturers to determine thicknesses of intumescent fire protection necessary to achieve a two-hour fire-resistance rating. Testing was conducted in accordance with CAN/ULC S101-07 "Standard Methods of Fire Endurance Tests of Building Construction and Materials" in test furnaces at Underwriters Laboratories of Canada in Toronto, Ontario, and Intertek Testing Services in San Antonio, Texas.

Even though the triangular-shaped diagrid members are installed vertically, diagonally and horizontally at the Bow, similar to the design of a large-scale steel truss, it was decided to test the diagrid members in accordance with the provisions for fire-resistance tests for the protection for vertical structural steel columns in CAN/ULC-S101-07 (individual member protection). Large-scale steel truss type structures cannot, because of their size, be loaded and tested in conventional fire-resistance test furnaces.

The Alberta Building Code recognizes the procedure for utilizing individual member protection on the basis that each component of a large-scale steel truss (vertical, diagonal and horizontal members) is evaluated as if it were a standalone column in a fire test furnace. The M/D ratio discussed earlier is then used to evaluate the overall fire-resistance rating of the truss type structure based on the least resistance provided by individual diagrid members. This approach is widely accepted and considered conservative in that:

a) The steel temperature limitations for determining fire-resistance rating of a protected structural steel column are more severe than the steel temperature criteria applied to steel trusses or joists supporting a floor assembly; and

b) Typically, floor assemblies incorporating steel trusses or joists support a concrete floor assembly which acts as a heat sink for the supporting structural steel joist and truss members, reducing steel temperatures. When tested as an individually protected column member, the heat sink benefits provided by the concrete floor are not realized.

Steel column assemblies were subjected to fire tests following the standard time-temperature curve with escalating temperatures rapidly reaching 538°C after five minutes and 1,010°C after two hours. The assembly fire resistance-rating is the period of time measured in hours that thermocouples attached to the steel record temperatures averaging not more than 538°C at any section of thermocouples, or 649°C at a single thermocouple.

Steel diagrid test columns, 2,750 mm in height, were fabricated at the steel fabricator that was awarded the Bow structural steel contract. One test column with minimum M/D ratio and one column with maximum M/D ratio were used for each intumescent coating type and test thickness. Steel specifications for fabrication of both test columns and the Bow diagrid structure required that surface imperfections be filled with each manufacturer's intumescent fire protection material in lieu of customary body filler to prevent uncontrolled foreign materials from influencing test results or creating uncertainty in the fire performance of the finished structure. Steel surfaces were sandblasted to meet the Society for Protective Coatings (SSPC) standard for the surface preparation required by the intumescent coating manufacturers. All test columns were prepared with a primer that was compatible with the intumescent coatings.

Thermocouples were attached to the steel diagrid columns prior to primer and fire protection application to monitor steel temperature throughout the tests. Twenty-three thermocouple locations were determined to emulate the distribution of data collection points stipulated for standard non-triangular steel shapes and with regard to anticipated failure resulting from either fire protection delamination or high temperatures at acute corners.

Columns were tested to the point of failure. Testing confirmed that the primary mode of failure was excessive temperatures experienced near acute corners of the Bow diagrid columns. All manufacturers produced column assemblies capable of achieving two-hour fire-resistance ratings. The minimum required thickness of intumescent coating for each of these diagrid member sizes was determined from the results of the fire-resistance tests. Fire protection engineering evaluations using linear interpolation methods were used, for each intumescent coating type, to determine the required minimum thickness of intumescent coating for steel diagrid members with M/D ratios between the minimum and maximums fire tested. Required intumescent coating thicknesses were thinner than utilized in conventional steel sections, resulting in more economical construction.

Other design considerations

Floor spaces at the base of atria are protected at low level with wall-mounted water mist sprinkler systems designed to NFPA 750 "Standard on Water Mist Fire Protection Systems" in lieu of conventional sprinkler protection at the ceilings of the tall atrium volumes. The water mist system is activated by operation of infra-red fire detectors monitoring the atrium floor areas. Full-scale fire tests with horizontal spray nozzles were conducted by the water mist system manufacturer. The full-scale tests were replicated using computational fluid dynamics (CFD) modeling to calibrate and validate the CFD software's emulation of water mist fire suppression.

The CFD software was then used to model fires in the Bow atrium spaces. A six MW steady state design fire was selected based on the type and quantity of combustible material within the atria, and to conservatively anticipate that the fire suppression system would prevent further fire growth upon activation rather than extinguish the fire. Modeling indicated that Bow water mist fire control will limit atrium ambient temperature beyond the edge of the fire to not more than 160°C, sufficient to prevent ignition of adjacent combustibles or damage of the diagrid structure.

In summary, determination of appropriate diagrid fire protection design and construction required the active and cooperative participation of many parties, including the developer, design consultants, steel fabricator and fire protection manufacturers, test laboratories, building authorities and construction trades. The result is a unique and compelling addition to the Calgary skyline.

Jon Winton, B. Tech., is Vice President Code Engineering, and John Roberts, P. Eng., is a Senior Associate with LRI Fire Protection and Building Code Consulting Engineers in Toronto. The firm provided building code consulting services on The Bow, including assistance to the owner with the design, fabrication, application, facilitation and analysis of results for the fire-resistance test program.


STEELDAY is COMING!
STEELDAY.CA
INTERACT. LEARN. BUILD. ON SEPTEMBER 28, 2012

News and Events

CISC SSEF Annual Convention

The 2012 CISC & SSEF Annual Convention & General Meeting will take place June 13 to 16 in our nation's capital – Ottawa. Ottawa offers visitors a wealth of quintessentially Canadian experiences.

CISC, along with the Ontario Regional Committee, has organized a number of great tours, including a cooking class and kayaking along the Ottawa River. You will experience the very best of what Ottawa has to offer!

We look forward to an exciting time for all of our members and guests throughout the four-day convention. As always, this year's convention is filled with educational seminars, marketing discussions and several wonderful and informative speaker seminars, providing opportunities to learn the latest in steel industry ideas, trends and research initiatives during daily business and marketing meetings. This year, we have some interesting topics that will be presented, such as "The Importance of Steel Manufacturing to Canada" and "Steel Design In Architecture." There will also be a variety of other interesting topics for discussion. Let's not forget the golf tournament, and we have also brought back Friday night's "Fun Night."

As well, this year we celebrate our second National Steel Design Awards! This event will be a gala evening of awards, dinner and entertainment.

There will be something for everyone at this year's convention. We look forward to seeing you there!

Corrections to Advantage Steel, Spring 2012

In Issue 42, the article "A span for all reasons" contained some errors. We regret and sincerely apologize for these inaccuracies. The Coast Meridian Overpass, not the Pitt River Bridge, was the longest push launch and the recipient of the CEBC Award. The Erector for the Coast Meridian Overpass was KWH Constructors Ltd., not KWH Structures. The Steel Fabricator on the Coast Meridian Overpass was George Third & Son.

Also in this issue, in the "List of Advertisers," the name of Canam Group Inc. was spelled incorrectly. We regret and sincerely apologize for this error.

Congratulations to Hugh Krentz, O.C.

Hugh A. Krentz has been made an Officer of the Order of Canada. This is for his contributions to the development of standards in the construction industry, leading to safer infrastructures for Canadians. Krentz, a long-time CISC member, was President of the organization from 1978 to 2001. For more information, please visit www.gg.ca/document.aspx?id=14390&lan=eng.

2012 marks 40 years for Supreme Group

2012 commemorates the 40th year for Supreme Group. To celebrate this remarkable achievement, they kicked off their year's celebrations on January 21 with their Annual Winter Gala, held at the Shaw Convention Centre in Edmonton.

Joining owners John and Sally Leder on this memorable evening were several hundred current and retired employees from all nine of their operations, located in British Columbia, Alberta, Saskatchewan, Winnipeg, Ontario and Portland. As well, current and former business associates, clients, friends and family joined them in observance of this milestone.

John Leder shared with everyone how it all began, how he and Sally got started in the steel fabrication industry, their early challenges with Supreme Steel and how they persevered to grow their company into the successful entity it is today, for the future benefit of the employee owners and their families. Supreme Group has become a leader in the industry with the help and support of their family and the many long-term, dedicated employees by their side. With this strong foundation built by John and Sally Leder, Supreme Group will continue to flourish into the future for many generations to come.

John Leder, President of Supreme Group, presenting a donation of $280,000 to the Salvation Army. The company celebrates its 40th anniversary this year.

Continuing Education Courses

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

Connections II for Steel Detailers
– New Online Course –

This twice-weekly evening course is the second in a two-part series intended to develop the skills necessary for the design of steel connections as related to the construction of steel-framed structures. The basic objective is to assist steel industry personnel in their understanding of basic connection design principles, and after a review of material presented in Connections I, to design more complex welded and bolted connections suitable for fabrication. Participants will also understand the origin of the rules and standards used in the steel industry. Satisfactory completion of Connections I is a prerequisite. Additional assignments and a final exam are used to qualify participants for a Certificate of Completion.

Course Leader: Royce Johnson, Waiward Steel Fabricators Ltd.

Webinar Format (20@2hrs)
Tuesdays and Thursdays, 7:00 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: 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., Engineering Manager, 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

Hot Topic Webinars
– New Online Series –

This series of 1.5-hour 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.

Fire Protection of Structural Steel
June 5, 1:00 - 2:30 p.m. ET
George Frater, Steel Market Development Institute

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

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 the rationale behind code provisions, as well as the application of specific Code formulae and requirements. It will cover the design of seismic resisting systems for 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.

	Seismic Design	Seismic Connections
Calgary, AB	May 28	May 29
Vancouver, BC	May 30	May 31
Montreal, QC (E)	June 19	June 20
Toronto, ON	June 21	June 22
Fredericton, NB	September 10	September 11
Halifax, NS	September 12	September 13

Conception de bâtiments industriels en acier

Ce cours permet de mieux comprendre la méthode de conception et le fondement des dispositions de code spécifiques aux bâtiments industriels à charpente d'acier. L'accent sera mis sur les solutions pratiques et économiques pour la charpente d'un bâtiment industriel type, conformément au Code national du bâtiment du Canada 2010 et aux dispositions pertinentes de la norme CSA-S16-01.

Montréal, QC	30 mai

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.

26 septembre	12 h - 14 h et 15 h - 17 h (HAE)
27 septembre	12 h - 14 h et 15 h - 17 h (HAE)

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.

New Members

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

Fabricators
AJ Braun
Resource Industrial Group
Modular Fabrication Inc.

Detailers
Infocus Detailing Inc.
MCN Steel Inc.

Associate Suppliers
American Iron & Metal L.P.
Ifastgroupe Distribution
HDIM Protective Coatings

Associate Erectors
Stampa Steel Erectors
M-C Steel Services Inc.

Associate Fabricators
Champion Ironworks Ltd.

Associate Professionals
Haijun Li, P.Eng
Julie Bui, P. Eng
Afshin Ebtekar, P.Eng
Alfredo Ilacad, P. Eng
Daniel Dumont, ing
Rémi Octeau, ing
Jozef Budziak, P. Eng
Stephen Barbour, P.Eng
Shane McShane, P. Eng

Associate Technical
Brett Clavelle
Patrick McManus

Associate Companies
MMM Group Limited
Entuitive Corporation
Amec Americas Limited
Groupe-conseil Structura international
Rouleau Desauniers s.e.n.c.

Regional Events

Alberta

The Steel Workshop
Keynote Speaker, Robert Forest, Partner and Co-founder of Adrian Smith Architects, Chicago
April 3, 2012, Radisson Hotel Airport, Calgary, AB
www.cisc-icca.ca/albertaworkshop

Events

AISC / ASCE Student Steel Bridge Competition
May 25 - 26, 2012, Clemson University, Clemson, South Carolina
www.aisc.org/content.aspx?id=780

2012 CISC & SSEF Annual Convention
June 13 - 16, 2012, Ottawa, Ontario
www.cisc-icca.ca/agm

International Symposium on Tubular Structures
September 12 - 14, 2012, London, England
www.istructe.org

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

Common Codes and Standards for Design and Construction of Steel Structures

Current Status and Future Publication Targets

CODE/STANDARD SUPPLEMENT/COMMENTARY	CURRENT EDITION	NEXT EDITION/ REVISION	PUBLICATION TARGET
National Building Code of Canada (NBC)	NBC 2010	NBC 2015	2015
NBC Structural Commentaries (Part 4 of Div. B)	NBC 2010 Str. Comm.	NBC 2015 Str. Comm.	
CSA S16 Design of Steel Structures	CSA S16-09	S16-14	2014
CISC Commentary on CSA S16 (Part 2 of CISC Handbook of Steel Construction[1])	CISC Handbook 10th Edition[1]	CISC Handbook 11th Edition	2015
CSA S6 Canadian Highway Bridge Design Code	CSA S6-06	S6-14	2014
- Supplements to CSA S6	CSA S6S2-11	S6S3-12	2012
CSA S6.1 Commentary on Canadian Highway Bridge Design Code	CSA S6.1-06	S6.1-14	2014
- Supplements to CSA S6.1	CSA S6.1S2-11	S6.1S3-12	2012
CSA G40.20/G40.21 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel	CSA G40.20-04 CSA G40.21-04 (R2009)[2]	G40.20-13 G40.21-13	2013
CSA W59 Welded Steel Construction (Metal Arc Welding)	CSA W59-03 (R2008)[3]	W59-12	2012
CSA W47.1 Certification of Companies for Fusion Welding of Steel	CSA W47.1-09	W47.1-14	2014
CSA S136 North American Specification for the Design of Cold-Formed Steel Structural Members	CSA S136-07	S136-12	late 2012
- Supplements to CSA S136	CSA S136S2-10		
CSA S136.1 Commentary on CSA S136	CSA S136.1-07	S136.1-12	late 2012

[1] CISC Handbook of Steel Construction - 10th Edition includes CSA S16-09, its Commentary, CISC Code of Standard Practice - 7th Edition, and design and detailing aids in accordance with CSA S16-09
[2] Reaffirmed in 2009
[3] Reaffirmed in 2008

CISC FABRICATOR MEMBERS

CISC Member Directory - Listing as of April 5, 2012

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

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. 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

Acier Trimax inc. S
Ste-Marie de Beauce, Quebec 418-387-7798
www.trimaxsteel.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
Donnacona, Quebec 418-285-4499
www.metalperreault.com

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

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
Québec, 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, Québec 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 Contracting Limited 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

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www.pittsburghsteel.com

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www.quadsteel.ca

Quest Steel Inc. B, Br, P, S
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Refac Industrial Contractors Inc. P, S
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www.resourceindustrial.com

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www.waltersinc.com

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www.capitolsteel.ca

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www.coastalsteel.ca

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www.iwlsteel.com

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www.angliasteel.ca

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www.cwcarry.com

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www.montacier.com

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