NO 40 SUMMER 2011

ADVANTAGE STEEL

ADVANTAGES OF CANADIAN STEEL SUPPLIERS

ECONOMICAL STRUCTURAL STEEL ON INDUSTRIAL PROJECTS

THE CAPITOL THEATRE PROJECT

THE SUPREMACY OF STEEL

TRANSFORMATION OF THE ART GALLERY OF ALBERTA

CONSTRUCTION OF A CURVED BOX GIRDER BRIDGE

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CANADIAN INSTITUTE OF STEEL CONSTRUCTION

FROM THE PRESIDENT

ELECTRONIC FRIENDS – YOU NEED THEM

Even the most conservative and geriatric of companies have come to realize that social media and a strong web presence are vital.

I am not suggesting that the steel industry is geriatric, but demographics suggest that most of our work force is in the fourth quarter of their careers. This year marks the start of the retirement wave of baby boomers, and now the younger generation will move quickly and swiftly into positions of power and influence.

This new generation is eager, talented, computer savvy and very social media driven. They communicate in ways many feel is unnatural and the opposite of social. With their heads bent on their BlackBerrys and eyes glued to Facebook, they interact with hundreds of friends around the world in seconds. This is the future, and the steel industry needs to engage this generation which will be replacing us.

Social media such as Facebook, Twitter and LinkedIn are just a few of the popular formats used by the next generation to interact. If we don't think these are powerful and effective tools, we need only look at how they were used during President Obama's 2008 campaign and the February regime change in Egypt.

It is said that online you either define your company or risk having others define it for you. So it is not a question of "if" you will implement a social media program within your company, but rather "when."

CISC's goal is to be the source and conduit of information, policy and social conversation for the steel industry. To that end you can now find us on Facebook at www.facebook.com/cisc.icca.ca, on Twitter at http://twitter.com/cisc_ca, and on LinkedIn at www.linkedin.com/company/986081. For those looking for technical information and discussion, visit our new CISC Steel Technical Forum at http://forum.cisc-icca.ca.

Ed Whalen, P.Eng.
President, CISC

IN THIS ISSUE

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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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TECHNICAL COLUMN

Alfred F. Wong, P.Eng.

This column highlights the answers for selected questions received from readers and others seeking technical information on steel structures. Suggested solutions may not necessarily apply to a particular structure or application, and are not intended to replace the expertise of a professional engineer, architect or other licensed professional.

QUESTION 1: Why have welded wide flange shapes been commonly used in Canada?

ANSWER: The introduction of CSA G40.12 in 1964 marked the beginning of an era for Canadian structural steel. This stronger (300 MPa specified yield) steel replaced ASTM A36 (248 MPa yield) steel as the basic grade for wide-flange shapes, etc. Algoma Steel, the Canadian wide-flange mill at that time, did not produce the full range of W-sections. As a result, the welded wide-flange (WWF) sections were introduced as alternatives for heavy rolled sections.

As built-up shapes, the WWF cross-sections can be tailored for optimal efficiency; standard beam sections were compact sections or stockier and all columns were Class 3 or stockier. Because the plates were oxy-flame-cut in Algoma's facility, their WWF sections were also qualified for the most favourable column design curve (of the three SSRC curves) whereas the least favourable curve applied to heavy A36 W-shapes.

The above-mentioned advantages, coupled with the higher strength of the 300 MPa steel, had helped WWF sections to remain popular choices for heavy sections until ASTM A992 (345 MPa specified min. yield) emerged as the common North American steel grade for wide-flange shapes about a decade ago. Until recently, WWF sections also benefited from the availability of notch-tough steel plates where required while rolled shapes, supplied to meet certain notch-toughness requirements, were scarce. Rolled W-shapes, up to 440 kg/m in weight and meeting CSA Type T Category 3 notch-toughness requirements, are now available (subject to minimum tonnage order, etc.). All in all, the clear advantages that WWF shapes once offered have dwindled.

QUESTION 2: Essar Steel Algoma has closed their WWF production facility. What are the steel designer's choices?

ANSWER: For several years, another source of WWF sections had supplied the market in western Canada. Following Essar Steel Algoma's exit, a large fabrication facility in eastern Canada has shown interest in WWF production. The future availability of WWF sections, or lack of, will be sorted out in the marketplace. It should be noted that WWF sections are essentially standardized welded built-up H-shapes (see answer to the question below). Hence they can be replaced with custom-designed welded built-up sections.

Here are the current choices: **a)** North American mills produce ASTM A992 rolled W-shapes up to 1,100 mm in depth, and column sections weigh up to 1,086 kg/m. At current exchange rates, they ought to be very competitive; and **b)** Welded plate girders for sections deeper than 1,100 mm and where the need to camber heavy rolled girders renders them unsuitable.

QUESTION 3: What are the major differences between Welded Wide Flange sections and welded I-girders?

ANSWER: Limitations for WWF shapes versus welded I-girders

- WWF shapes are restricted to a maximum depth of 2,000 mm.
- WWF shapes are standardized sections whereas plate girder cross-sectional dimensions may vary.
- WWF shapes are straight members.
- WWF shapes have a limit on built-in camber (though they can be quite versatile).
- The web-to-flange weld strength of WWF shapes is limited to the capacity of a 20 mm web.
- A cross-section change involves splicing 2 WWF sections whereas a plate girder cross-section change may involve changing the size of 1, 2 or 3 plates.
- Butt-welded splices are permitted in WWF production; when fatigue is a design consideration the production splice details must be accounted for.

Dimensional tolerances:

WWF shapes are supplied to the requirements of CSA G40.20 whereas welded shapes should comply with W59 requirements. These standards share essentially identical tolerance requirements for length, camber, web flatness, combined warpage and tilt and lateral deviation between centreline of web and centreline of flange at contact surface. The under-tolerances for section depth are also identical. W59 has no provision for flange width tolerances but G40.20 does. It should also be noted that tension testing of the web-to-flange welds is part of the WWF production requirements.

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.

SEISMIC CORNER
STEEL SEISMIC-FORCE RESISTING SYSTEMS

Alfred F. Wong, P.Eng.

How to select the right SSFR for your project

Requirements incorporated in modern codes and standards have made seismic design increasingly challenging. NBC 2010 describes many seismic-force resisting systems, SFRS, and imposes use restrictions for some. Structural steel SFRS must also comply with the requirements of CSA Standard S16-09. S16-09 specifies other restrictions where applicable as well as design and detailing requirements for each system. Many parameters and factors affect the seismic effects and design requirements. Most influential factors may be ranked in descending order as follows:

1. Locality – accelerations; values of accelerations also dictate the choice of SFRS, method of analysis, regular layout and continuity, uniform stiffness distribution, etc.

2. Soil – site properties have a marked effect on seismic response.

3. Importance category – larger forces for buildings in a higher Importance category; it also dictates the choice of SFRS, regular layout and continuity, uniform stiffness distribution, method of analysis, etc.

4. SFRS – larger force reduction for SFRS with larger ductility, R_d, and larger reserve strength, R_o.

5. Building mass – seismic forces are proportional to building mass.

6. Building height – dictates choice of SFRS and method of analysis; wind effects may dominate the design of tall buildings.

7. Building configuration – affects structural configuration, and the irregularities, if any, trigger more stringent requirements.

8. Stiffness distribution – affects torsional effects and method of analysis.

9. Mass distribution – affects torsional effects and method of analysis.

10. Wind effects – may dwarf seismic forces and affect the choice of SFRS.

The structural engineer usually selects the SFRS and should also choose the material for the structure that typically makes up a larger portion of the building mass. He or she usually has some degree of control of the stiffness distribution. Provided the stiffness distribution is within reason, it typically only affects the torsion forces and deformation and, in conjunction with seismicity, determines the choice of methods of analysis.

Regarding building mass, a steel structure is significantly lighter than a concrete or masonry structure. That leaves us the SFRS, and the challenge begins. Obviously the object is to pick the SFRS for economy and performance. Before we begin our search we must take our first step: to determine what systems are permitted by the building code. We will focus on the first step in Part 1 of this article.

Figure 1: Steel Seismic Systems Roadmap 2010 - Input

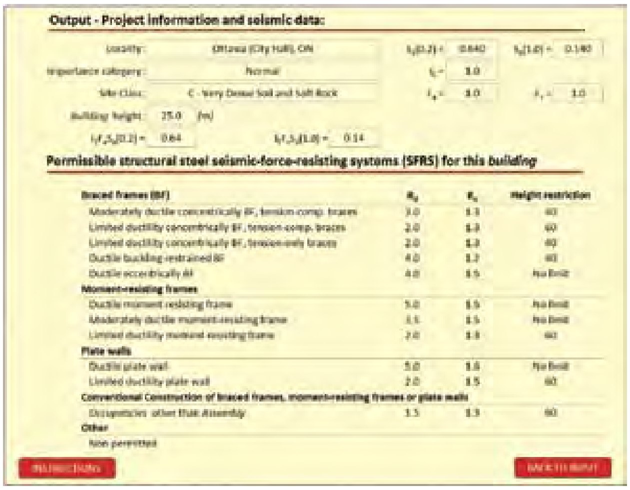

Figure 2: Steel Seismic Systems Roadmap 2010 - Output (25 m)

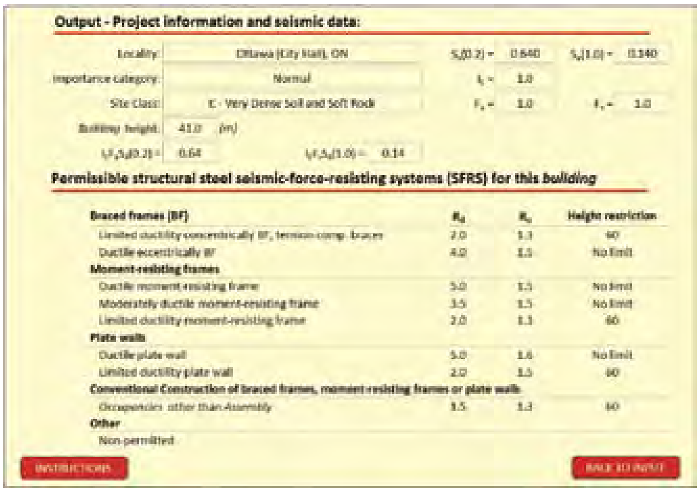

Figure 3: Steel Seismic Systems Roadmap 2010 - Output (41 m)

Let us consider the factors in descending order of their influence:

a) Importance category (post-disaster?), I_E

b) Locality - accelerations, S_a

c) Soil - Site factors, F_a and F_v

d) Building height

e) Building mass

f) Geometry/architectural layout

g) Wind effect

h) Mass distribution

Given factors b) and c), the Design Spectral Acceleration value, S(0.2), can be determined. When S(0.2)≥0.12, earthquake load and effects must be considered. Table 4.1.8.9 in NBC 2010 prescribes the permissible SFRS depending on factors a) to d). In addition, the importance category alone can dictate the use of more ductile systems, e.g. post-disaster buildings must have SFRS qualified for $R_d \geq 2$.

Let us consider a 25-metre tall office building, situated on Site Class C, in Ottawa. The "Steel Seismic Systems Roadmap 2010" developed by CISC is used to arrive at the list of permissible SFRS for this building quickly. Figures 1 and 2 show the input parameters and output summary respectively. For this example, the NBC 2010 and S16-09 disqualify only three systems listed in Table 4.1.8.9, "Moderately Ductile Tension-only Concentrically Braced Frame," "Conventional construction of moment-resisting frames, braced frames or plate walls" for assembly occupancies, and "Other" (undefined) systems. Note that if the building height is increased to, say 41 metres, "Moderately Ductile Tension-compression Concentrically Braced Frame," "Limited Ductility Tension-only Concentrically Braced Frame" and "Buckling-Restraint Braced Frame" will also be disqualified.

Copies of CISC Steel Seismic Systems Roadmap 2010 are available at: www.cisc-icca.ca.

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Structural steel is a leader in sustainable design and return on investment

FOR GREEN'S SAKE
A SUSTAINABLE SOLUTION

Sylvie Boulanger, Ph.D., P.Eng.

A sustainable solution is an integrated one employing several strategies and many materials to produce a high-performance building. Steel's attributes — recycled, recyclable, reused, adaptable, low waste, low site disturbance, adaptable, aesthetic — make it an important player for a greener tomorrow. The goal of this column is to help design team members take advantage of those attributes for green's sake. This issue provides an overview of the advantages of steel in the context of green buildings and LEED.

Steel is a sustainable construction material, is technologically sophisticated, and has streamlined fabrication capabilities. All steel produced today is made with recycled content without loss to quality or performance — this can be achieved infinite times through the recycling process. Using Life Cycle Analysis (LCA), the benefits of steel become apparent as it fulfills the long-term mandate of sustainability through the 3Rs, making steel a true cradle to cradle product.

REDUCE I REUSE I RECYCLE

Reduce. Energy efficiency in the Canadian steel industry has improved by 26% since 1990 (canadiansteel.ca). Greenhouse gas emissions have been reduced by 24% in intensity (per tonne) since 1990. Air and water emissions are 90% lower today than 10 years ago. As a highly prefabricated system, steel can reduce construction periods by 60% and require 75% fewer operatives on site, with consequential benefits to the client, contractor and local community. Steel reduces the building weight and footprint by accommodating longer spans with smaller member sections.

Reuse. Designers reuse elements of a steel structure on-site or have them dismantled and rebuilt elsewhere without loss of steel's basic properties. Slag, a by-product of steel, is fully recovered and reused for road building, cement substitutes and other applications. Gases produced during iron making are used for reheating.

Recycle. More steel is recycled each year than paper, aluminum, glass and plastic combined. Of the 99% steel recovered at the end-of-life of a steel building, 15% is locally reused and the rest is recycled.

The inherent recycled content of steel is the highest of any structural material.

In North America, there are two main methods used to make structural steel. More than half is produced using the mini-mill

Two thirds of the raw material going into steel is scrap metal - 90% is trucked within a radius of 800 km *Photo: Adam Korzekwa*

Electric Arc Furnace (EAF) which relies on virtually 100% recycled steel. The integrated mill produces steel with the BOF (Basic Oxygen Furnace) process and up to 35% recycled steel (recycle-steel.org/leed.html). Adding post-consumer and pre-consumer recycled contents typically delivers average LEED values of 40% to 50% — well exceeding the credit's objective.

Together, EAF and BOF processes ensure a globally sustainable development of steel in construction today. The international CO2 Breakthrough Programme is currently developing solutions to reduce the impact of these processes in the future.

THE BOTTOM LINE

Sustainability is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own." It rests on three pillars: social, environmental and economic.

Social - Steel fabrication uses technologically advanced production methods, provides safe working conditions and a product that is aesthetically pleasing.

Environmental - Steel is repeatedly recycled and reused, is energy efficient and allows for long-lasting lightweight construction.

Economic - Steel has low labour and production costs, faster erection time, an ability to generate revenue sooner and is less expensive to change during use than other materials.

LEED

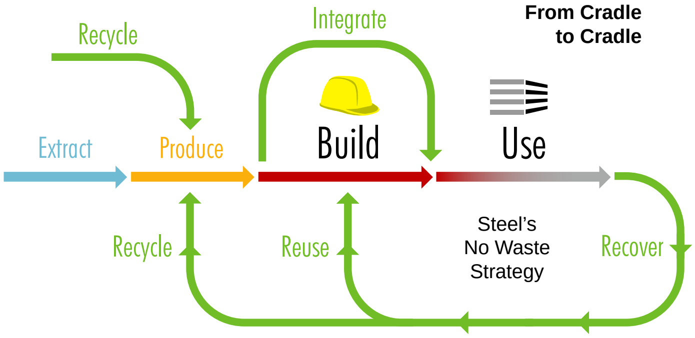
Leadership in Energy & Environmental Design (LEED) is a green building rating system. Managed by the Canadian Green Building Council (cagbc.org), it encourages and accelerates global adoption of sustainable green building and development practices with tools and performance criteria.

Steel consistently helps designers acquire points in LEED MR credits for recycled materials (two points), regional content (two points) and reuse (two points) — totalling six of the 14 points available for "materials."

In use, steel integrates and works with other materials such as glass in a double skin façade, concrete in a radiant floor heating system or wood in a hybrid system. As a result, steel has an impact on the entire life cycle and contributes points to not only one but several LEED categories.

For more information visit www.cisc-icca.ca/sustainability.

More steel is recycled each year than paper, aluminum, glass and plastic combined

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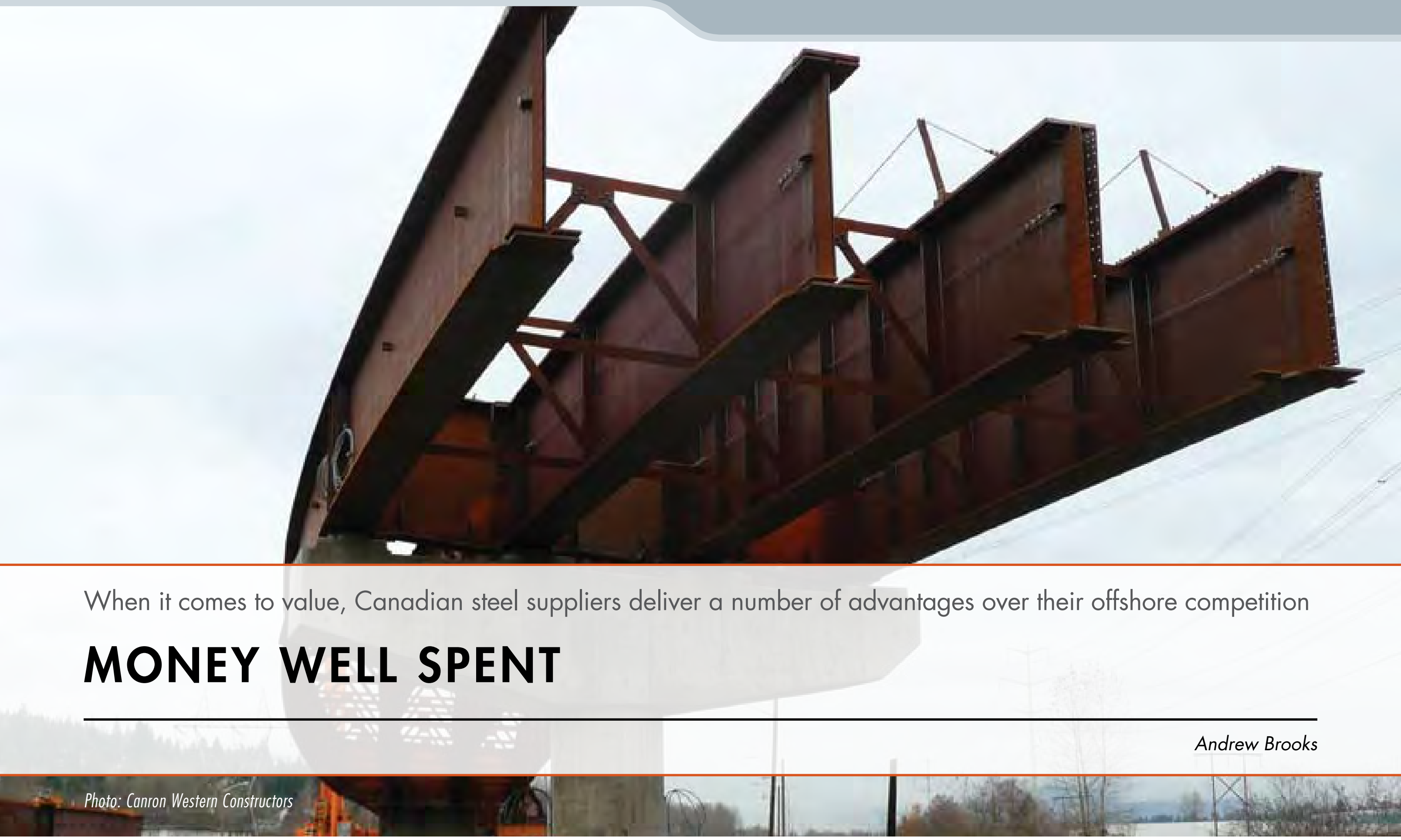


Photo: Canron Western Constructors

When it comes to value, Canadian steel suppliers deliver a number of advantages over their offshore competition

MONEY WELL SPENT

Andrew Brooks

Sometimes, going with local suppliers is more than a question of cutting down on shipping costs. Canadian steel fabricators are a prime case in point. The work they do is recognized for its quality around the world, with customers from every corner of the globe lining up because they know they are getting the best work available. (See "Home Run Across the Border" in *Advantage Steel No. 37* for one example.)

Everyone in the industry agrees that Canadian standards of workmanship — and of workplace safety — are as tough as you'll find anywhere. Objective third-party audits keep Canadian fabricators at the top of their game, and when fault is found, prompt corrective action is mandated and followed up.

There are more advantages. A supplier based close by knows local conditions — climatic, geographic and regulatory — and can respond to the unforeseen changes and hitches that always come up. You can develop a solid working relationship with a Canadian fabricator that you just cannot have with someone halfway around the world. And, yes, there are the shipping costs we mentioned up-front. Hardly a trivial matter.

For all that, work in Canada is increasingly being supplied to offshore fabricators — a trend that gained speed in the last ten years or so, says Ed Whalen, President of CISC. "We've seen it during the Alberta boom, but everywhere else in Canada too. Especially on larger projects, in oil and gas for example. They're tendered by large engineering companies and others who contract steel fabrication offshore."

Steve Ross, General Manager of Cherubini Metal Works, has also seen the phenomenon develop. "Through globalization, a lot of companies now have a tendency to shop internationally," he says. Ross contrasts this state of affairs with the situation that prevailed only a few years ago, when Canadian fabricators could usually count on getting a good slice of work on large-scale projects in their own neighbourhood.

TO WHAT END

Why is it happening? Firstly, a low sticker price becomes much more of a selling point when times are tough, budgets are tight and when the efficiencies of container shipping mean that it doesn't cost a king's ransom to send cargo thousands of miles. When the Canadian dollar is riding high, the deal is even better.

But that low sticker price is just the tip of the iceberg. Top-line savings can come at the cost of serious and expensive problems down the road. At the end of the day, Whalen says, a Canadian fabricator can save multiples, for a whole lot of reasons.

Location, location, location. That's the magic formula in real estate, and it turns out to be one of the most compelling arguments for dealing with Canadian fabricators. Containerization may have subdued the expense involved in global shipping, but that isn't the whole story.

Photo: Canron Western Constructors

Photo: Canron Western Constructors

Photo: Cherubini Metal Works

Photo: Cherubini Metal Works

"Logistics are still a factor," says Paul Collins, CEO of Collins Industries. Collins is based in Edmonton where, as in many other parts of Canada, inclement weather makes it essential to deal with someone who understands what weather can do to a construction schedule and is close enough to adapt.

"If it's going to be 50 below in Fort McMurray for five days and the site will be shut down, an Edmonton fabricator won't ship," Collins says. "They can communicate quickly and easily; (there are) no time zone problems or different languages to deal with."

Shipping from overseas may be surprisingly cheap, but in most cases the shipment isn't directly to the project site. It might be to a company marshalling yard or, just as likely, to the nearest major seaport. The final hauling is still the responsibility of the buyer.

More seriously, the high-volume model that makes container shipping so cost-efficient also means that shipments aren't blocked or broken out to arrive as needed on site. In the interest of efficiency, all beams can be in one container, all columns in another, etc. So components have to be broken out and kitted or blocked on site or in a nearby yard. Add the time and expense of assigning a skilled workforce to find matching components and put them together, and the savings of offshoring quickly evaporate.

For Steve Ross, minimized shipping time means less likelihood of damage. "Having shorter hauls means less handling of the steel," he says. "That's really important when you think about the multi-coat paint systems involved in industrial type work. If steel arrives with lots of handling damage, it can be rejected on site, which obviously has a major effect on the schedule."

Photos: Cherubini Metal Works

GOOD RELATIONS

"Canadian fabricators will usually also erect the steel," says Harrison Wilson, General Manager of Ocean Steel & Construction Ltd. "Offshore suppliers just supply it. It's a real advantage to have the same guys supply and erect the steel. Then it's their responsibility to deal with problems like misfits, delays, missing pieces, rejections, etc., and it doesn't add to the bill for the customer."

When different parties are responsible for those elements, glitches lead to disputes and even legal action.

What's more, says Collins, fabricators based in the same market are far more likely to design connections that are more economical to use in erection. Offshore suppliers are less interested in whether the connections they provide turn out to save money and time on-site.

"Absolutely you will get better connections using a Canadian fabricator," says Walter Koppelaar, President of Walters Inc. "They're used to working in this country, they're used to working with erectors here so they know what the local practices are. They know the local skill levels, and they know what equipment is available."

Koppelaar recalls an experience he had buying an end mill from an overseas supplier. "We had to rewire the whole thing — the wires weren't coded or numbered," he says. Once working, the unit performed well, and a couple of years later they ordered two more. "We found that under the orange paint, the welds around the base were just epoxy filler. That wouldn't happen here, but with an overseas supplier, it did."

If the epoxy "welds" had been made to structural steel members, the consequences could have been catastrophic.

Jim McLagan, Vice President of Canron Western Constructors Ltd., has personally experienced the problems that can arise in preparing shop drawings that an overseas fabricator can work to. The thought of offshoring when a middleman is involved doesn't fill him with confidence. "As a fabricator we know our business, but a general contractor who goes offshore doesn't," he says. "An offshore contract requires much closer management because of the problems that you can have."

While McLagan doesn't like to name names, he recalls one project Canron lost to a low-price offshore bidder. "We couldn't do it for the price the construction company wanted, because that was less than our cost," he says. "So they went overseas instead."

As it turned out, the guaranteed start and finish dates Canron provided would have saved the customer big-time, since the project wound up starting late and then faced significant stoppages and delays. To make matters worse, the erector ultimately back-charged the constructor for far more than Canron's margin would have cost. On top of the expense of placing staff overseas and on-site to prevent problems, McLagan says the constructor almost certainly didn't save by going overseas.

"We have engineers on staff," he says. "When there are design issues, we don't have to wait for an answer. We can provide it right away. The specialty nature of our trade requires some specialty knowledge."

"Canadian steel fabricators have expertise in the best way to fabricate steel," Collins says. "We can add so much value — simplifying the connection process, choosing right-size members. Our fabricators know better than anybody what's available, what's easiest to put together and what brings the best value to the customer. That's where you're missing lots of value when you go offshore."

In the end, the key is thinking in terms of "best value" as opposed to "best price."

A look at the unique considerations of economical structural steel on major industrial projects

ECONOMICAL STRUCTURAL STEEL ON MAJOR INDUSTRIAL PROJECTS

Greg Miazga, P.Eng.

Over the years many helpful articles on economical structural steel construction have appeared in engineering journals and industry publications. These articles remind us of an important objective: good structural design must not only satisfy building code and owner requirements, but must also allow economical and fast construction. Many of the suggestions in these articles have been applicable to all types of steel construction; this article focuses on considerations for major industrial projects.

These are large-scale projects constructed to produce a product or process — versus large buildings primarily constructed for human use and occupancy. They often require billions of investment dollars, several years for design and construction, hundreds of engineers and technicians, and involve thousands of design drawings, tens of thousands of shop drawings and tens of thousands of tonnes of structural steel.

UNIQUE CONSIDERATIONS

Major industrial projects have many unique characteristics:

- A variety of structural configurations, functions and serviceability requirements;
- Unusual load types, such as impact and cyclic loads, and transportation loads if the project is assembled (modularized) off-site and shipped to the site;
- Large investment capital that usually results in fast track (tight) schedules;
- A situation where the civil/structural discipline is often the last to receive information required to complete their design work, but is the first group required to start construction; and
- A structural steel contract that is usually based on unit prices, as design on the entire project is not completed when construction needs to start.

A SMALL PLAYER?

Historically, structural steel has often been considered a small player in the overall scope of major industrial projects because the cost of structural steel is a small component of the total cost. However, with ever shortening construction schedules, the sequence and duration of steel design and construction can have an enormous impact on the overall project cost and schedule. In fact, on tight project schedules, the engineering, fabrication, delivery, erection and fireproofing of structural steel is frequently on the critical path of the project.

Following is a summary of some of the more important "dos and don'ts" for designers and owners to consider regarding structural steel on major industrial projects:

DO:

1. Think: Total installed cost (TIC)

By now, most people in construction are familiar with the phrase total installed cost (TIC). To provide economical structural steel, TIC causes one to consider all the cost components that combine to form the final completed cost — not just say material costs or fabrication or erection costs in isolation.

For structural steel, the significant cost components are generally considered to be material procurement, engineering and detailing, fabrication, shipping and erection. Other cost components are perhaps not as obvious: project management, coatings, inspection, safety costs and material handling (including lay down areas and possible storage).

While the objective of minimizing costs through TIC is acknowledged by most designers and owners, many remain fixated on the initial supply cost (fabrication) of structural steel, at the expense of the other cost components. Focusing solely on minimizing the fabrication costs may, for example, result in prohibitive erection costs and a higher TIC.

Consider fireproofing of structural steel. It is usually prudent to maximize fireproofing of steel members in a shop environment, thereby minimizing the costs of more expensive field fireproofing, including scaffolding, field inspections, etc. To maximize shop fire-proofing, the connection details used for steel fabrication are often more complicated (and expensive) than standard connections, resulting in a higher steel supply cost but a reduced TIC of the installed fireproofed steel.

Extended shear tabs are a connection type that is more expensive than a standard shear connection, but can substantially reduce field fireproofing costs. Welded frames are also more expensive to supply than stick built members, but when used in fireproofed areas, welded frames can substantially reduce the TIC by reducing the number of "blocked out" areas of shop fireproofing needed to make the field connections.

2. Have early fabricator and erector involvement

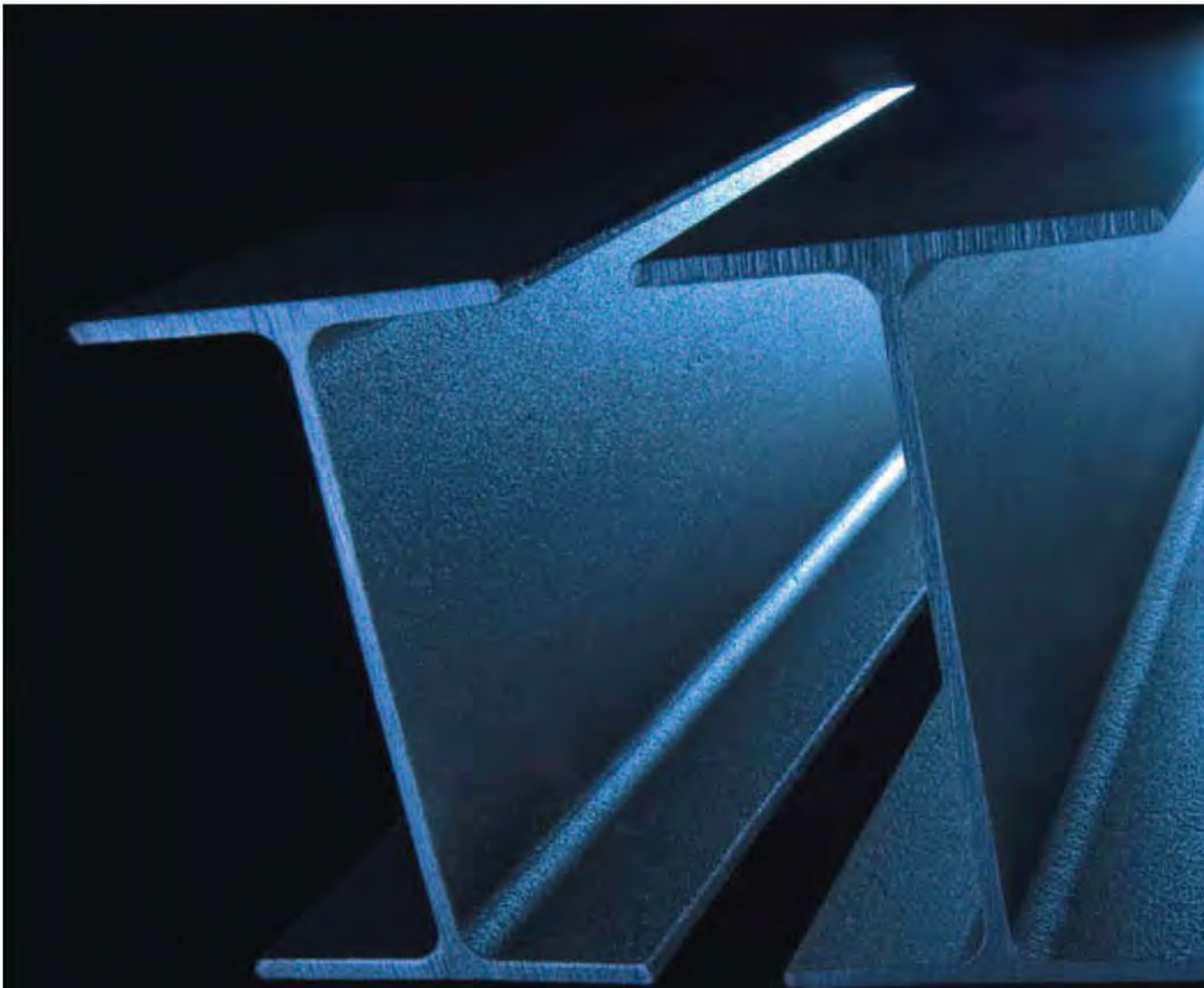
For major industrial projects, engage the fabricator and erector as early as possible in the design phase of the project. Why early? History has shown that the best opportunities for reducing costs and/or schedule on major projects occur in the early critical planning stages. A technically competent fabricator and erector can provide engineering, modelling, scheduling and project management support, including cost studies, help optimize connections and participate in specification and constructability reviews in the early stages of a project. Regarding technical competency, capabilities such as quality management, management support, engineering and drafting resources, construction support and track record should be considered.

How early? The most successful major project the author has participated in — for the owner, engineer, fabricator/erector and constructors — occurred when the fabricator/erector was contractually engaged a full year prior to starting fabrication. The substantial upfront collaborative time allowed optimization and planning of many construction aspects, even to the degree where the fabricator could match piece mark nomenclature to the engineer's material management system for accurate tracking and costing of the work.

3. Have a well thought-out structural steel construction strategy

This may appear obvious, but it is important for the structural steel program to be well planned from the beginning to avoid schedule delays. The following are significant considerations:

- Construction sequence, expected (and realistic) cycle times for construction work packages within the overall project;
- Site labour costs and availability (module versus stick-build construction, welding versus bolting);
- Fabrication contract strategy: lump sum versus unit price;
- Location(s) of fabrication;



- Fabricator, coating, fireproofing contractors;
- Shop/erection/document control review and management system (preferably electronic);
- Off-site (module) yard steel erector, if used;
- Site Erector;
- Shipping and lay down area management; and
- Plan for managing changes: how will they be done and who will do them?

An example of a frequent shortcoming in structural steel planning on major industrial projects is that the time required to process shop and erection drawings through owner/engineer document control systems (for engineering review and tracking control) is not consistent with the expectations for short cycle times of construction work packages. Alternative "work around" procedures to bypass document control systems are often developed to expedite the work, resulting in a loss of control on the project.

4. Use material sizes that are most available

The CISC Handbook of Steel Construction lists all the possible section sizes that are available in North America. However, on fast-track projects designers should consider limiting section sizes used to those that are rolled by mills most often and are therefore most available. Guidance on the availability of sizes can be obtained from fabricators or from mills. If sections must be used that require longer lead times from mills, the designer should identify these early on and consider preordering them prior to the release of design drawings. Bottom line: design using section sizes that are consistent with the expected cycle times on your construction work packages.

5. Group member sizes and types when appropriate

Current design and analysis computer programs make use of the full library of possible steel shapes to generate least weight structural solutions. Least weight solutions may be the most structurally efficient, but are not necessarily the most cost effective. After a preliminary design is complete, grouping of member sizes can often result in a less costly steel solution, through savings in ordering, inventory and material handling costs during fabrication.

6. Know that the major costs are in the connections and details — do not just focus on member strength design

On major industrial projects steel material costs are often only 20% to 30% of the overall TIC of structural steel, yet often the least weight steel solution is assumed to be the least cost solution. The remaining 70% to 80% of the TIC is highly dependent on cost of connections. Here are some important considerations:

- Use actual (realistic) loads for connection design: Do not use specification requirements such as "design moment connections for 100% of the capacity of the weaker member framing into the joint." Unnecessarily high connection capacity requirements come with a significant cost.
- Avoid joint reinforcing such as stiffeners and web doubler plates: To avoid expensive joint reinforcing, members for some connection types need to be sized with the connections in mind, such as for moment connections, HSS connections and trusses.
- Welding: There should be few CJP welds required for statically loaded steel — substitute fillet welds or PJP welds where possible. If possible, avoid seal welding and in general, try to minimize field welding.
- Bolting: Consider ways to minimize the bolt count (connection design criteria, use larger bolt diameters, allow single sided connections, only use slip critical joints when absolutely needed).

7. Proper design and modelling

Modularization of major industrial projects is becoming an increasingly common construction practice for remote sites. A module is a portion of a structure that is pre-assembled off-site (with equipment installed, where labour costs are lower) and then transported to site.

Each module is designed to be structurally stable for transportation and installation. Sometimes large complex structures are constructed from many site installed interconnected modules, and the design for lateral stability of the final structure must be integrated into the design of the individual modules.

Perhaps with the advent of these complex modularized structures, it is becoming more common for fabricators to receive engineering designs with multiple lateral load resisting systems, and hence very expensive connections. An example would be structures that appear to be fully laterally supported by a vertical bracing system and also by a system of moment connected framing. Another common modelling oversight resulting in expensive connections occurs when a designer fixes moment connections in multiple directions when only one direction is required.

8. Consider "Issued for Procurement" (IFP) drawings for ordering of steel

On major projects cycle times can be reduced by producing IFP drawings for main steel in advance of IFC drawings.

9. For "super rush" construction cycles, consider "Issued for Detailing" (IFD) drawings

IFD drawings (for detailing only, not for fabrication) at, for example, 80% design completion, can allow even further reduced cycle times on specific work packages by pre-detailing the primary structural elements of a construction package prior to the release of IFC drawings. Once the IFC drawings are released, final design arrangements and details are incorporated in detailing. Pre-detailing major structural framework can vastly improve delivery times for relatively small added detailing costs.

10. Consider one contractor for fabrication, shipping and erection

Many fabricators are also competent erectors and can manage shipping effectively. Consolidating these construction functions under one roof is perhaps the single most effective step that can be taken to deal with changes that will inevitably occur in major projects (design and/or priority changes).

11. Know that revisions are a project killer

Not surprisingly, at the conclusion of most major projects, design revisions are usually targeted as the primary source of most of the cost and schedule over-runs. Knowing this:

- Once IFC drawings are issued, it is game on: Do not think that changes to a design will come easily after IFC drawings are issued. It is usually wiser to delay issuing IFCs — to get the IFCs right — than issue partially complete drawing to meet a drawing release schedule.
- Have a clear plan for when, where and who will do revisions — and stick to it. Everyone wants to have all revisions done in the shop rather than the field — even last minute revisions — but this can be very inefficient, delaying the schedule for whole construction work packages.

DON'T:

1. Do not change the construction priority plan

On major projects there can often be a disconnect between designers and construction planners: the designers are working to a different priority list than construction. Sometimes designers issue drawings in an area of lower priority simply because they have all the information needed to complete the design. This can result in the fabricator working to a schedule that is out of sync with construction requirements.

2. When changes must occur, do not rely on sketches and emails (only) for communication, versus updating design drawings

Years ago, designers issued revisions to design drawings as the norm for communicating design changes. More recently, design change notices (DCNs), or some similar communication system of sketches and notes, have been utilized when design changes need to be expedited without taking the time to go through drafting and document control systems. On some major projects, this has led to using DCNs as the normal way of communicating changes after the initial release of IFC drawings, foregoing the updating of design drawings. Major schedule, tracking and change management problems can occur if the only complete structural steel construction drawings are the fabricator's erection drawings.

Figure 3: Near completed construction by Supreme Steel

A case study in file to fabrication to field integrated delivery

THE CAPITOL THEATRE PROJECT

Peter Timler P.Eng.

The Capitol Theatre Project in Fort Edmonton Park, Edmonton, AB, represents a very successful case study in Integrated Delivery within a collaborative BIM (Building Information Modeling) environment. The building is comprised of conventional all steel framing with composite steel deck to form a two-storey, multi-use, entertainment complex of approximately 1,210 square metres encompassing about 110 tonnes of fabricated works.

The execution of the project was led by visionary architect Allan Partridge, currently Vice President at the Canada BIM Council and then Partner with HIP Architects (now with Group2 Architecture Engineering Ltd.). Partridge enabled standard operating protocols that set out the framework for a non-conventional delivery method. For the structural steel supply and installation scope, he established a goal of zero formal Requests for Information (RFIs) to the assembled design team; hence early involvement with an experienced fabricator was sought to work in a fast-paced joint design setting.

Supreme Steel LP of Edmonton (Supreme Steel), part of the Supreme Group LP (Supreme Group), was comfortably nominated by Stantec, structural consultant on board, due to previous success in early involvement collaborative scenarios. Most recently this was in a Design – Assist role on the completed Edmonton International Airport – Air Terminal Building Expansion Project.

Supreme Steel accepted the challenge. They rolled up their sleeves, sat at the table immediately, and became engrossed in the process of marshalling information flow relative to the structural steel scope. Their quotation for services, which included structural BIM coordination, detailing (development of compatible 3D Manufacturing Model (3DMM)), fabrication and installation, was accepted by the project team and was assigned to the Construction Manager, PCL Construction Management Inc. Also, CadMax of Boisbriand, Quebec, teamed with Supreme Steel for the detailing services and complemented in-house expertise for this short notice opportunity.

Although Supreme Group, through its numerous steel fabrication operations, has strong experience collaborating within BIM environments, what set this project apart was the architect's commitment to a comprehensive adherence to integrated discipline design within a virtual venue. Thus, advanced involvement of the steel fabricator included regular interoperable exchange of the 3DMM, produced in Tekla Structures, within the Single Purpose Unified Revit (Architecture 2010) (SPUR) Model hosted by the project architect (Figure 1).

The interoperable interchange of data between the steel fabricator and the design team produced numerous benefits to aid in the rapid deployment of information for fabrication through accelerated approval practice. To understand this, the refined network of information sharing requires explanation.

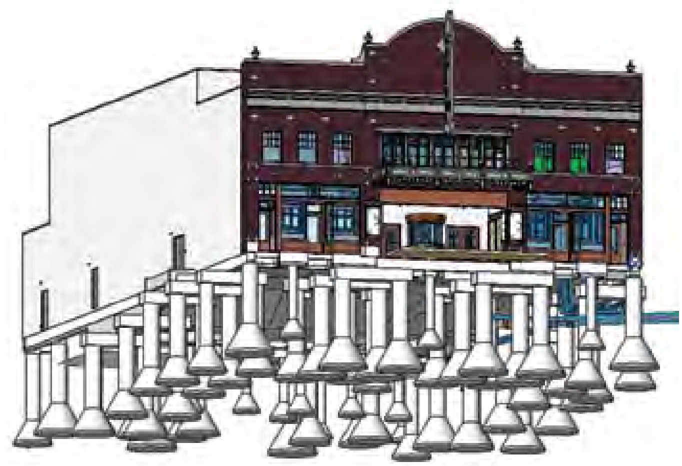


Figure 1, left: Architect's Single Purpose Unified Revit (SPUR) Model

Figure 2, below: Supreme Steel's Tekla 3DMM

Capitol Theatre

OWNER: City of Edmonton
ARCHITECT: HIP Architects
STRUCTURAL ENGINEER: Stantec Consultants
CONSTRUCTION MANAGER: PCL Construction Management Inc.
FABRICATOR: Supreme Steel LP
DETAILER: CadMax
ERECTOR: Supreme Steel LP

Upon the structural form having been established within the SPUR file to the accuracy level required for construction purposes, an IFC file was prepared for import to Tekla as a Reference Model (downstream information conveyance) (Figure 2). Once within the Tekla platform, all structural elements were converted to "native" elements.

While this conversion process can be seamless, for a number of reasons, most attributed to incorrect element data assignments within the SPUR, some easily identified and manageable Tekla file adjustment occurs. Following the standard work procedures within the Tekla 3DMM that steel fabricators are accustomed to, an IFC file is prepared for SPUR acceptance (upstream information conveyance). The downstream/upstream data swap-over constitutes true interoperable information exchange in the virtual environment. The imported information is saved within the architect's realm as a stand-alone Revit Model before linkage and overlay into the SPUR.

Within this file interchange protocol, it is important to understand the contractual obligations relative to any potential and unintentional altercation of data, hence two necessary rules were employed: 1) data from the native model prevailed over exported data, and 2) should discrepancy exist between the BIM 3D Models and any 2D documents generated, the 3D Model information would govern.

File transfers from the Tekla 3DMM to the SPUR were performed on a near daily basis. Because the steel detailing software is specialized in further downstream data generation for plant floor information, i.e., shop drawings and CNC (Computer Numerically Controlled) instructions which drive automated equipment, it is logical that "live" work within the SPUR file would not occur as with some other disciplines. The collaborative design team were therefore able to regularly view the progress of steel frame refinement within the structure, including design progress changes and their impact on other building material interfaces.

Throughout the design cycle process of reliable synchronized updates to the SPUR, efficiency gain through architect and engineer virtual review and approval process occurred. The design team gained in knowledge on the impact of steel framing development, and conversely, the steel fabricator witnessed how the overall building evolved. This process eliminates costly "working in a vacuum" design practice since sophisticated "viewing" is available to all parties involved without investment in expensive software or onerous training for its use.

The virtual integrated delivery approach also allowed for substantial value engineering adjustments to be made during the design process by Supreme Steel as well as numerous recommendations to coordinate previously intended miscellaneous scope works, i.e., stairs and catwalk supports, for much less costly integration into the primary steel construction package.

The project's steel construction (Figure 3) was executed without IFC (Issued for

Construction) paper release which is contrary to conventionally executed means and was erected, essentially flawlessly, in a time frame estimated to be about three months shorter than the norm. When taken into context of this relatively small project, such a schedule gain was tremendously advantageous as the structure could be enclosed before inclement weather conditions occurred which could slow down other construction trade's progress.

Much was learned from the process by all involved and some recommendations for improvement have been developed. Probably the most important lesson for the design team to have experienced was their process of project execution to diminish the importance of information development in media other than the SPUR. Hence, reliance on the experienced steel fabricator for management of all steel related information frees up their resources for higher level project functions and decision making.

For those that are interested in the ownership/liability issues that could mire such a process, the project architect provided leadership and direction to the entire team in the forward of the standard operating protocols that read like this:

"There are, without a doubt many issues that can be laid out and I do not want to marginalize any concerns about liability, responsibility, risk, etc. We could quickly get bogged down in them and we end up in discussions that superimpose adversely on the schedule we face for Capitol Theatre. So let's be generally right and move ahead than try to be prescriptively correct and go nowhere." Allan Partridge AAA, MRAIC, MAIBC, LEED® AP, SCO.

Through such an opening, the architect set the stage on trust through open communication, and all parties involved bought in. As for the SPUR model ownership, following design completion, the model was transferred into the hands of the General Contractor to manage the remaining building trade tendering and development of the As-Built Record. In the end, the model was handed over to the owner.

Supreme Steel looks forward to working with the same and similarly focused design/construct teams on future projects where "bringing better value" to the project can be amply demonstrated for project owners. By the way, architect Allan Partridge's vision of zero RFIs during the structural steel design and fabrication process for the project was achieved!

For more information, please contact Peter Timler at the Supreme Group at: peter.timler@supremegroup.com.

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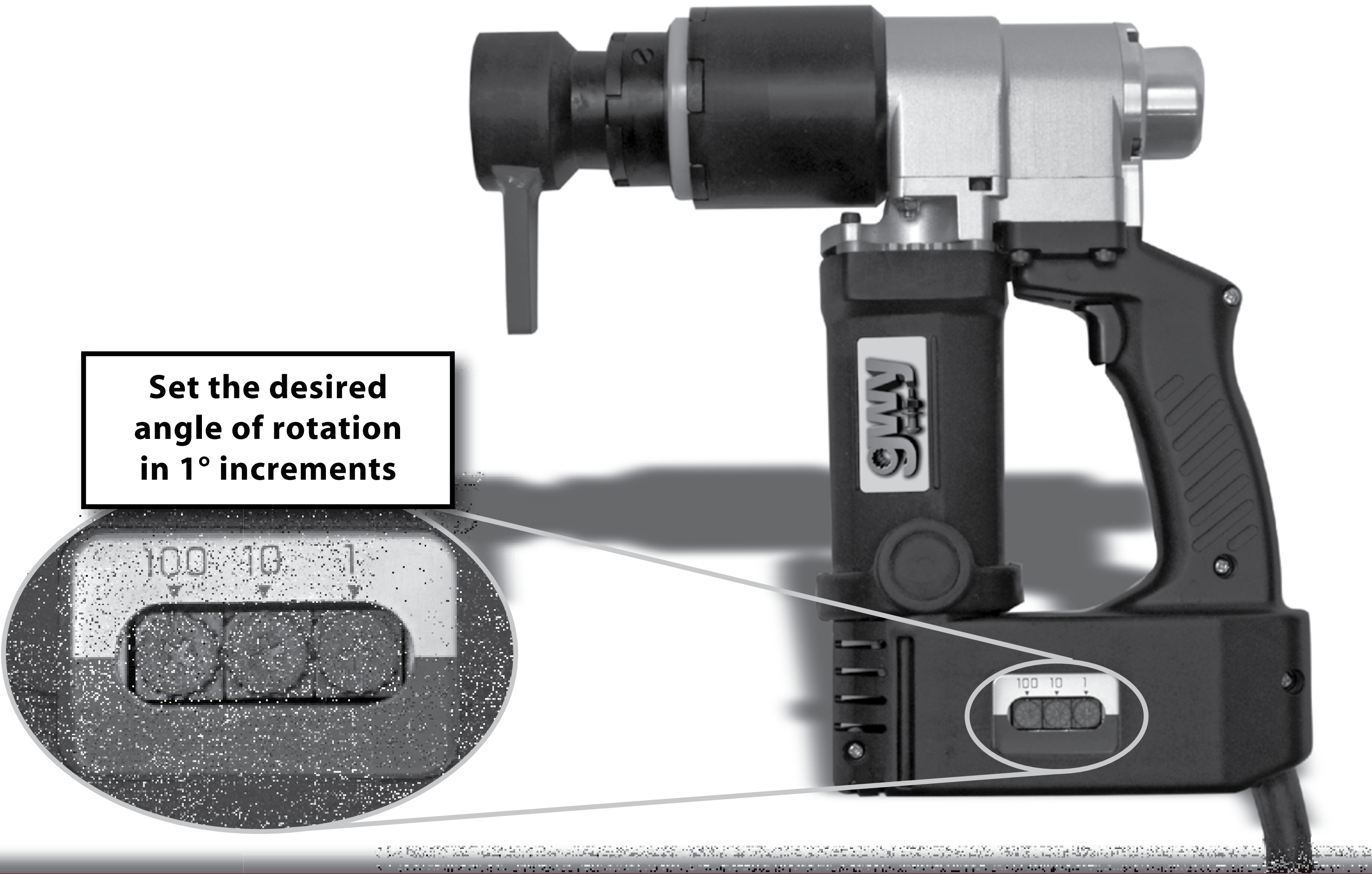

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The atrium winter garden at Calgary's Eighth Avenue Place

Two recent projects in Alberta illustrate why steel is gaining a reputation as a best-in-class material for unique, contemporary structures

THE SUPREMACY OF STEEL

Kelly Parker

Given the distinct advantages of using structural steel — strength, speed of erection and light weight among others — it's curious that concrete is often the go-to material for designers almost by default.

In fact, two recent Alberta projects — Eighth Avenue Place in Calgary and The Edmonton Clinic Health Academy — were originally leaning toward concrete construction, but steel allowed both to accomplish design elements that make them unique.

EIGHTH AVENUE PLACE

Eighth Avenue Place currently comprises a single glass tower with plans for a second — which together will add over 1.8 million square feet of office space to the Calgary skyline. The striking look of the buildings was enabled by steel, rightly described as a "best-in-class material" by its owners in their promotions.

Rising some 50 storeys, Eighth Avenue Place is subject to significant wind loads, meaning that the chosen material for the structural system, core columns and floor framing would have to be driven by the system that best resists the lateral wind forces.

Engineers did four different schemes for the cost comparison: an all-concrete building, an all-steel-frame building, a concrete shear wall and outrigger steel frame. "A fourth — composite super columns and interior core bracing system was not consistent with the architectural design, although the costs were in line," explains Luke Groeneveld, Project Engineer with RJC Structural Engineering.

A shear wall and uniform outrigger system was the one that was ultimately used, "employing outrigger beams at every floor — the outrigger girders that support the floor framing — which gives a better deflection behaviour," says Groeneveld, "especially at the top of the building, where there is not as much width. It's more of a smooth deflection lateral drift behaviour."

Along with wind response, there are two other reasons why concrete was not used on this project. Because of the aforementioned propensity to go with concrete in Calgary, when this project was in the design and tendering stage, concrete crews were exhausted. The second was scheduling. Concrete construction is slower than steel, typically taking about seven days to turn over a floor and often involving crew overtime, whereas steel allowed the contractors to do it in five days.

"At one point," explains Groeneveld, "there was a request to speed up assembly to get the mechanical systems operational for partial occupancy of the lower half of the building. That raised

Photo: Roy Ooms/Lightworks Photography

This steel outrigger system is what makes Eighth Avenue Place unique and perhaps the only one of its kind

Eighth Avenue Place

OWNER: Penny Lane II Limited Partnership
ARCHITECT: Architect of Record: Gibbs Gage Architects
ASSOCIATE ARCHITECT: Kendall/ Heaton Associates, Inc
DESIGN ARCHITECT: Pickard Chilton International
STRUCTURAL ENGINEER: Engineer of Record: Read Jones Christoffersen Ltd.
DESIGN ENGINEER: Ingenium, Inc.
PROJECT MANAGER/GENERAL CONTRACTOR: EllisDon Construction Services Inc.
FABRICATOR/DETAILER/ERECTOR: Supermétal Structures Inc.
DEVELOPMENT MANAGER: Hines

schedule issues, which were overcome because the use of steel allowed things to be sped up to a rate of a floor every three days — much quicker than they could have achieved with concrete."

Steel also enabled designers to incorporate the somewhat eccentric look inherent to the project. The north facade slopes heavily toward the south, and in order to accommodate that, the structure retracts toward the south. That was done with inclined steel columns rather than with transfer beams. "With concrete," says Groeneveld, "you can't slope your columns like that. You have to use these transfer beams, and they become prohibitive for depth, and they are also difficult and time consuming to construct."

In the end, this steel outrigger system is what makes this building unique and perhaps the only one of its kind. The system involves an inbedded beam with rebar dowels robotically welded to the piece. This system involves 537 imbedded beams with more than 12,000 rebars.

"The core is free-standing, so there was no steel anywhere near it to receive the outrigger beams later on," explains Groeneveld. "That was something that I don't think had ever been done before in Canada, and our consultants from the States were not aware of this being done anywhere south of the border either, so it was very unique. Even if it had been done before, it would still have been unique."

THE EDMONTON CLINIC HEALTH ACADEMY

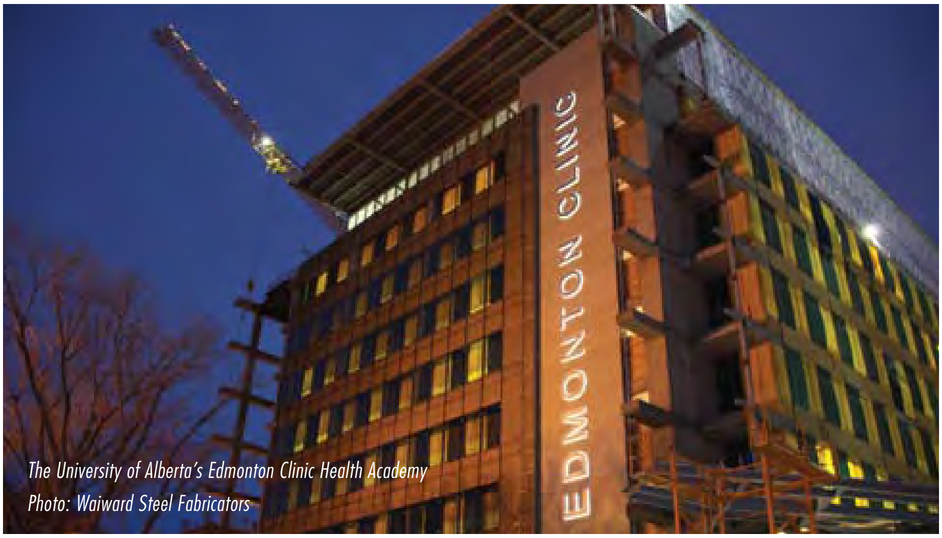
The University of Alberta has been doing some building of its own with the construction of The Edmonton Clinic Health Academy (ECHA).

As with the Calgary project, it looked for a time that this Edmonton project might be rendered in reinforced concrete.

"The University of Alberta challenged the construction manager to have a lower cost on the project, so they were very interested in making sure that steel got fair consideration," notes Jim Montgomery, the Structural Engineer on the project, along with Jeff DiBattista, both Principals in the Structural Group at Dialog, and Eric Gordon and Zia Khan of Halcrow Yolles Ltd.

During planning, the structural team did a fairly complete conceptual design of the building in both structural steel and reinforced concrete, which Montgomery says resulted in "a pretty heads up comparison between the costs of the two systems."

There were other factors that also came into play. "The original design for ECHA had some bays with long spans to accommodate



The University of Alberta's Edmonton Clinic Health Academy
Photo: Waiward Steel Fabricators

Steel proved an economic advantage for the Edmonton Clinic Health Academy *Photo: Waiward Steel Fabricators*

lecture halls, so we felt that a steel system should be given close consideration for the building," says Montgomery. Eventually many of the long spans in the lecture hall areas were reduced in length, which Montgomery says took away from the advantage of using steel over concrete. He adds that the soil conditions on the site weren't ideal for taking heavy loads, which made the lighter weight of steel construction even more attractive.

In addition to those design factors, further detailed cost analyses found that there was also an almost $1.5-million economical advantage in going with steel.

That's not to say that the decision process didn't get a bit "involved," as Montgomery puts it, partially because of what he refers to as a propensity toward concrete in the Alberta marketplace. "Along the way," he says, "we had to overcome the biases of the contractors who were used to using concrete and the architects who had to visualize the project in a slightly different way."

Once the decision was made to create ECHA in steel, the people at Structal Heavy Steel Construction set to work on the process the company has in place that would eventually see the steel work come in roughly four weeks ahead of schedule. "We have a plant in Sunnyside, just south of Edmonton," explains Jacques Renaud, Structal's Project Manager for ECHA, "so all of the fabrication was done there. We also have a tremendous drafting team of five or six engineers that worked on the connection design, and a specialized team to make the core connections according to the structural specifications. While that was happening, we were bringing in the steel for fabrication, and all of that overlap combined to move the project along quickly."

Ultimately, the University of Alberta has a finished project it can be proud of. "I think that it's interesting to have such an important steel structure in Edmonton where traditionally this type of structure would probably be done in concrete," emphasizes François Briere, Structal's Vice President of Business Development. "So we're pretty proud that structural steel was used for this building. It was a good project."

The Edmonton Clinic Health Academy

OWNER: University of Alberta
ARCHITECT: HOK (collaborating architect Stantec Architecture Ltd.)
STRUCTURAL ENGINEER: Halcrow Yolles/Cohos Evamy Joint Venture
CONSTRUCTION MANAGER: PCL Construction Management Inc.
STEEL CONTRACTOR: Structal-Heavy Steel Construction, a division of Canam Group
DETAILER: InteliBuild, a division of Canam Group
ERECTOR: Montacier International (subcontractor of Structal-Heavy Steel Construction)

The AGA reinvents itself with an impressive new design inspired in part by the aurora borealis

THE TRANSFORMATION OF THE ART GALLERY OF ALBERTA

Trevor Hobbs, P.Eng.

The Art Gallery of Alberta is a centre of excellence for the visual arts in Western Canada, expressing the creative spirit of Alberta. The gallery itself is a work of art that complements and completes the cultural community surrounding Churchill Square and solidifies Edmonton as a world-class city.

The team developed thermal break details where the steel penetrated the building envelope to avoid forming a "cold bridge" which would compromise the museum quality interior space of the gallery

The gallery features increased exhibition space, dedicated gallery space for the permanent collection of art, expanded education facilities, restaurant, gallery shop, 150-seat theatre and a collection of unique rental spaces both indoors and out, including an atrium that exhibits the creative use of steel.

The Art Gallery of Alberta public spaces are reinvented in a language of sinuous structural steel supporting stainless steel surfaces, peeling off of one another and creating opportunities for generous views and natural light within the building. The design was inspired in part by the aurora borealis, the night sky phenomenon that is most readily observed in the northern region that is home to Edmonton and its new Art Gallery. The project, 7,800 m^2 (84,000 sq^2) in total, will add 2,500 m^2 (27,000 ft^2) of new public spaces and galleries and will include approximately 2,230 m^2 (24,000 ft^2) of interior exhibition space relying on structural steel as the superstructure.

Since the grand re-opening in January 2010, the Art Gallery of Alberta has enjoyed a substantial increase in both attendance and gallery memberships, and has been able to host international exhibits featuring collections by Matisse, Degas, Goya, Escher and Karsh.

SCOPE

The project comprised the renovation of a portion of the 1960s Brutalist concrete structure to provide an upgraded theatre, educational space, galleries and back of house areas; a rectangular two-storey vertical expansion straddling the existing structure containing the new third floor gallery and fourth floor administration levels; and the soaring angular atrium enclosing dramatic public spaces framed by the sinuous ribbon of the borealis that is the defining element of the structure.

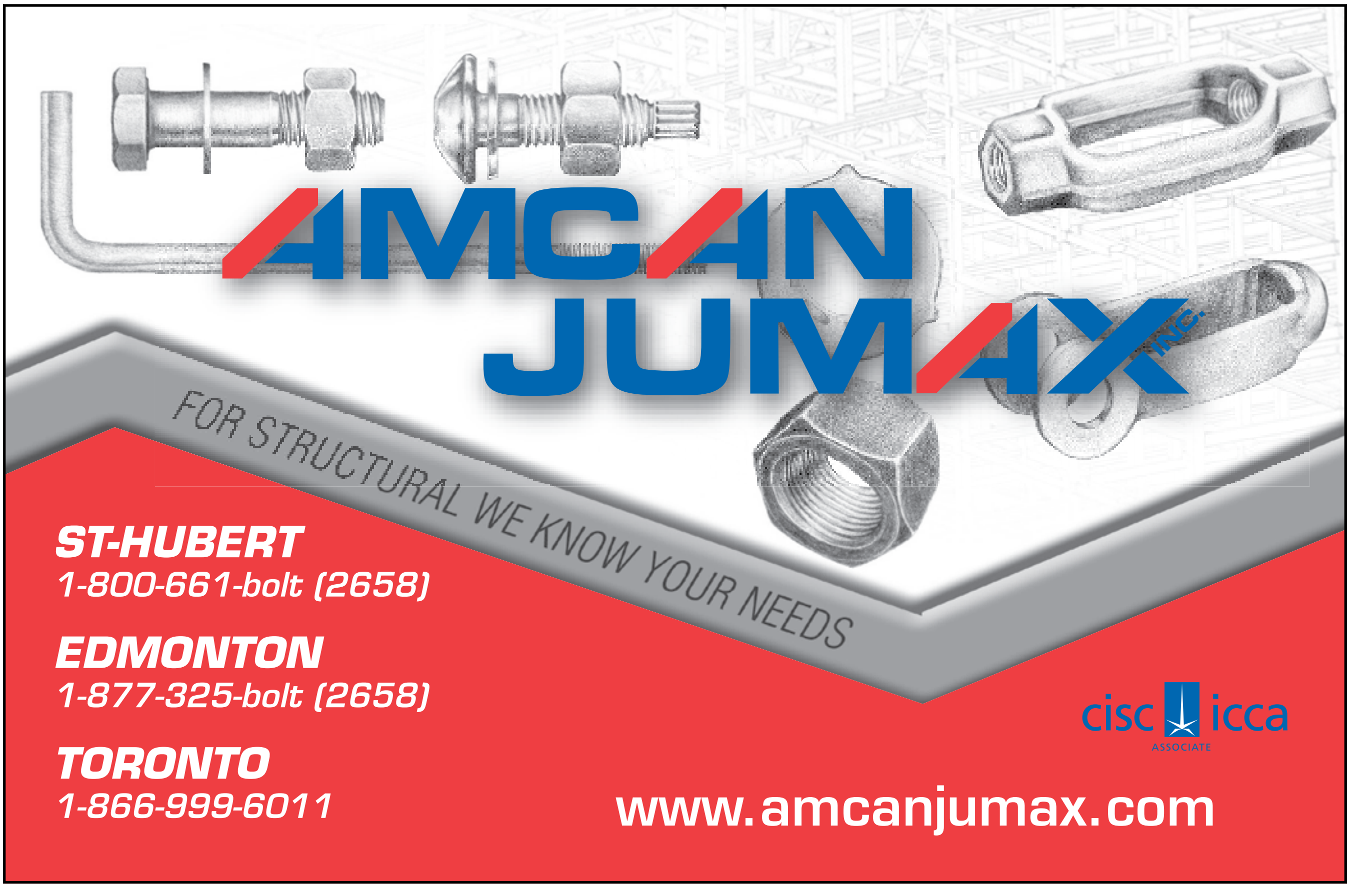
VERTICAL EXPANSION

Structural steel was the obvious choice for the new vertical addition to minimize the impact on the existing structure below while providing maximum usable space of 930 m^2 (10,000 ft^2) at each level. Single-storey trusses frame the north and south walls, each supported by three W360x551 (W14x370) columns that thread down through the existing structure and bear on pile caps

Atrium and roof framing: borealis frame on the terrace roof being "skinned"

Erection of a pre-clad section of borealis frame

Photos: Empire Iron Works Ltd.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supported by 40-ton screw piles installed in the existing basement. The trusses are cantilevered at the east and west ends, allowing the floors to extend over the sidewalk and loading dock below. Floor and roof framing of W920 (W36) and W760 (W30) beams spans between the trusses and provides a gallery space that is completely unimpeded by structure members, offering the maximum flexibility for both large and small exhibitions.

While the detailing and fabrication of this area was straightforward, the size and weight of some of the members presented installation challenges. Limited access on the north and east sides, and a rapid transit tunnel to the west, limited crane placement and reach. The solution was to install several temporary columns to support the cantilevers until the trusses were fully erected.

ATRIUM & BOREALIS

The angular glazing planes forming the building envelope of the atrium, and the curving, reflective metal-clad borealis surfaces that penetrate it at multiple locations, work together to animate the building, expose the activities within, and engage people and art at multiple levels on both the interior and exterior. Due to the complex geometries, minimal clearances and tight tolerances, steel was again the clear choice for structural support.

For the atrium, wide-flange members as large as W360 x W551 (W14 x 370), hollow structural sections up to HSS406 x 406 x 13 (HSS16 x 16 x 0.500), and custom box shapes 460 x 460 (18 in. by 18 in.) comprised of 38 mm (1.5 in.) plates were used to create the unique forms. Connections were a challenge in both hidden and exposed locations. Shop fabricated hubs were designed to transfer the large forces, including torsion, and accommodate the complicated geometry — up to five main members at one location varying in both size and orientation.

Exposed locations were also reviewed for appearance, while the configuration of the hidden hubs was often constrained by the limited space available within the structure and the need to support framing members that extended through the building envelope.

The large steel frames that support the borealis were fabricated from round and square hollow structural sections (HSS), and are completely hidden within the cladding of the final structure. Members were rolled to the geometry generated by the Tekla Structures model, and

Architectural rendering of the new AGA building used in the competition *Photo: Randal Stout Architects*

Art Gallery of Alberta

OWNER: Art Gallery of Alberta
ARCHITECT: Randall Stout Architects, Inc.
ENGINEER: DeSimone Consulting Engineers
GENERAL CONTRACTOR: Ledcor Construction Ltd.
STEEL DETAILER, FABRICATOR & ERECTOR: Empire Iron Works Ltd.
CLADDING SUPPLIER (BOREALIS & ZINC): A. Zahner Company
CLADDING INSTALLER (BOREALIS & ZINC): Flynn Canada Ltd.

individual pieces were joined by fitting CNC fabricated cut ends and fillet welding the joints. Procedures were developed for checking and maintaining tolerances during the fabrication and erection of these complex assemblies.

The team developed thermal break details where the steel penetrated the building envelope to avoid forming a "cold bridge" which would compromise the museum quality interior space of the gallery.

BIM

Team members practised lonely BIM using Tekla Structures, Rhino, Pro/ENGINEER, CATIA and AutoCAD to coordinate, collaborate and communicate, and to proactively manage, design and construct the project.

The steel detailer created a basic model from the Architectural Rhino model and the CATIA model from the structural engineer. Secondary and miscellaneous steel was then manually added to the model. Reference models from the cladding supplier were used to determine the location and orientation of support clips, and the location of the steel members was checked against the building skin model to ensure that connection plates and other steel members did not "daylight" through the enclosure surfaces.

Traditional shop drawings were submitted simultaneously with 3D models for the architect to import into the master model as a final check before fabrication. Data from the model was also used to fabricate and check the shop jigs, and to verify the site installation. Site survey data was imported into the model, and then sent to the cladding supplier and installer to verify that the panels could be installed properly. Except for minor deflection issues, all support clips were within the specified tolerances.

PROJECT SUCCESS

The success of the project was achieved through the general approach of the owner, architect, engineer, general contractor, cladding supplier and installer, steel fabricator and other team members who were willing to share models and information, and who pushed the bounds of the available technology. The team was able to openly discuss and resolve the many issues associated with a structure of this complexity, and successfully complete the construction of this challenging, exciting, and rewarding project.

The construction of a curved bridge with steel box girders over Autoroutes 15 and 640 limits traffic interruptions on Montreal's North Shore

UP TO THE CHALLENGE

Nikolay Velev, Eng., M.App.Sc.

The high population increase and socioeconomic development of Montreal's North Shore have triggered an increase in highway traffic and the need for new developments in Ville de Boisbriand. The optimum configuration of the traffic lanes requires construction of several ramps, as well as repair and widening of the existing bridges. Eleven new bridges will be built in all. The longest and most impressive is bridge PO 11555C, a curved bridge with steel box girders.

DESCRIPTION OF THE BRIDGE

The geometry of the highway, the highways to be crossed, and aesthetic criteria were the determining factors in choosing the PO 11555C spans. In view of these considerations, the bridge deck is made of a continuous structure of three curved spans 49, 52 and 36 m long, with an average curvature radius of 120 m, and another straight continuous structure of two 45 m spans (Figure 1). Given the lengths of the spans and the 5 m minimum clearance required under the structure, the chosen deck section is formed of two steel box girders spaced 4.6 m centre to centre. In addition, the cost, the requirement to keep the lanes under the bridge open to traffic at all times, and the maintenance of the structure were other factors indicating steel as the reasonable choice for this structure. Compared to a post-tension concrete structure, steel can be erected faster, since it does not require formwork or long highway closings under the bridge. These are determining factors, in view of the traffic nerve centres at this location.

The thickness of the top flanges varies from 30 mm on the span to 50 mm above the piers, while the thickness of the bottom flanges varies from 20 mm on the span to 50 mm above the piers. The webs have a constant height and thickness of 1,700 mm and 14 mm, respectively. They are also inclined according to a slope of 1H: 4V in relation to the section plan. The concrete slab is 8.940 m wide and 0.200 m thick. For the curved part, the intermediate vertical braces inside the boxes are spaced about 3.0 m apart and the vertical braces located between the

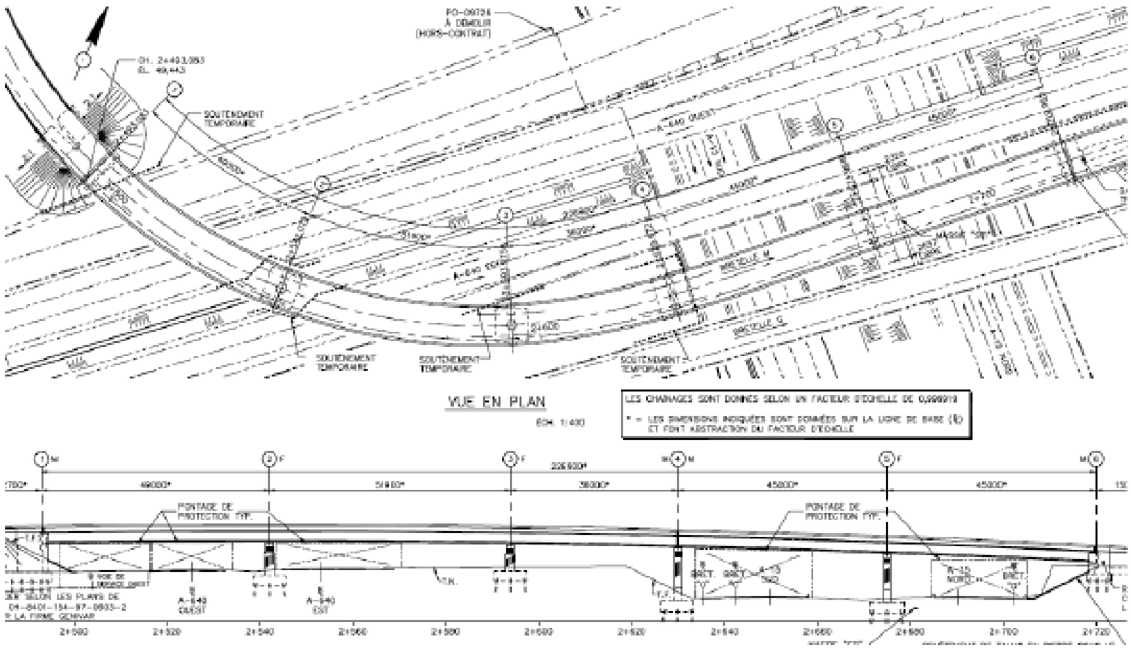


Figure 1. Plan view and elevation view of the bridge

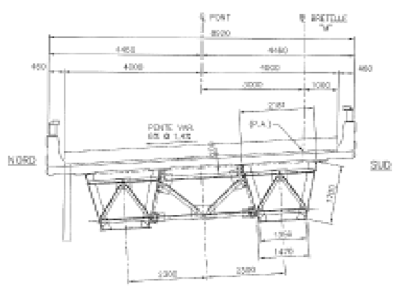


Figure 2. Typical section on the span

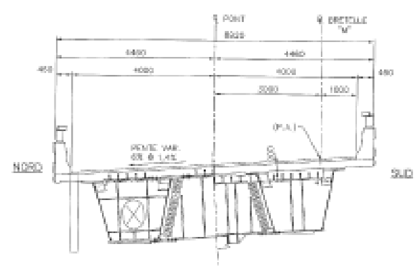
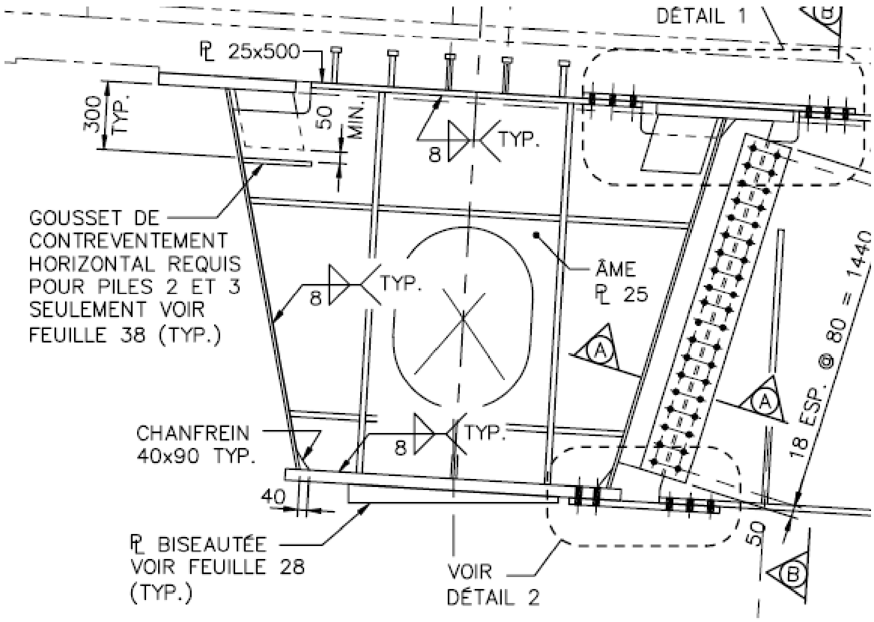
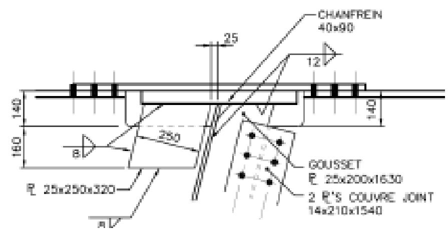


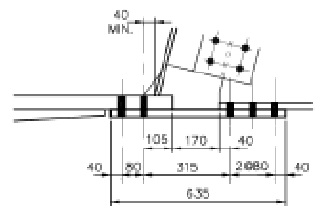
Figure 3. Typical section on the supports

Figure 4.a) Assembly of external and internal diaphragms of the supports





b) Detail 1: Assembly of the top flanges



c) Detail 2: Assembly of the bottom flanges

two boxes are positioned every 6.0 m. In the straight part of the bridge, all the vertical braces are spaced about 7.3 m apart. The diaphragms on the supports are made of solid web girders. To allow inspection inside the boxes, access traps are developed in the bottom flanges of each girder near the two abutments and pier 4. Access openings were also developed in the diaphragms above piers 2, 3 and 5 to allow access to all the spans. Figure 2 shows a typical deck section on the span, and Figure 3 shows a deck section on the supports.

DESIGN

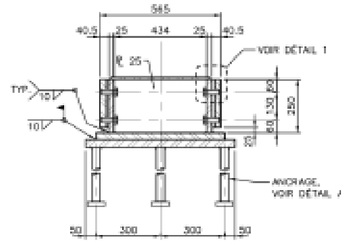
From the beginning of design, special attention was paid to the manufacturing and erection methods of the steel structure and transport of the sections. An economic analysis performed according to the lengths of the plates available, the lengths of the segments transportable by truck, and the cost of making the joints at the plant and on the site made it possible to determine the number and the optimum positions of the construction joints.

Despite the fact that the design of curved bridges is much more complex than that of straight bridges, there are few specific design requirements for this type of structure in the Canadian Highway Bridge Design Code, CAN/CSA-S6-06. There are also few typical assembly details developed for steel curved box girders, which was one of the major difficulties related to this project.

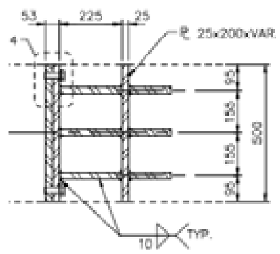
MODELLING

The analysis and the detailed design were completed by using two types of models: a mesh model and a 3D finite element

Figure 5. Earthquake bumper



b) Fixed segment section



c) Moving segment section

a) Elevation

model. Certain parameters of interest, such as the support reactions, the maximum displacements, the shear forces near the supports and the bending moments near the piers, obtained with both models, were compared to validate the models used.

SPECIFIC DETAILS

The complexity of the forces acting on the box girders and their special geometry impose additional requirements on the assembly details of the members constituting the steel structure. Among the most important recommendations, we should mention that:

- The details used must facilitate the future inspection of the boxes; the details of assembly of the diaphragms to the supports must be adjusted to account for the high torsional rigidity of the box and the installation methods;
- All the details must be designed to minimize the fatigue stresses;

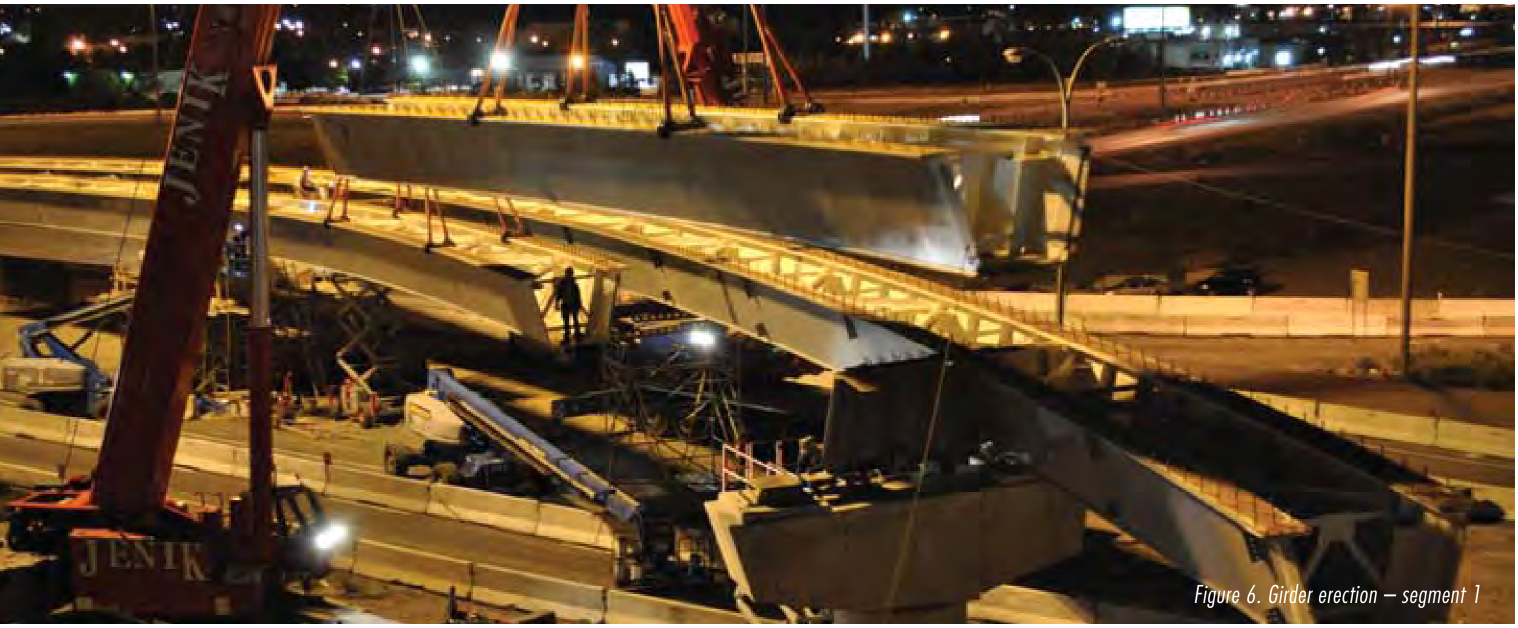


Figure 6. Girder erection – segment 1

- Application of a coat of pale-coloured paint inside the box to facilitate future inspections and crack detection.

The diaphragms external to the supports, designed as deep girders, are subjected to bending caused by shear and torsion in the box girders. The large bending moments acting on the diaphragms required the development of an assembly that remains rigid during bending (Figure 4.a). Special attention was given to the fatigue details to ensure natural direct transmission of the forces.

To avoid weakening the section above the piers and causing fatigue problems, the plate connecting the top flanges of the internal and external diaphragms (Figure 4.b) is not fastened to the flange of the box. However, the bottom flange of the diaphragm is fastened to the bottom flange of the box by a bolted plate (Figure 4.c). This detail does not weaken the section in negative moment and does not introduce fatigue problems, because the bottom flange of the box is compressed constantly. To avoid introducing eccentricity into the assembly, the diaphragm web is bolted with two connection plates to the box's outer stiffener. To facilitate installation all the holes of this assembly are oversized.

To pick up the lateral seismic forces on the joints, combined with longitudinal movements, bumpers were designed with replaceable components, located between the two boxes (Figure 5). The bumper system consists of two parts: a fixed part installed on the foundation unit and a moving part fastened to the external diaphragm between the boxes.

ERECTION OF THE STRUCTURE

Erection of the metal structure began from axis 6 to axis 1 and was performed overnight with lane closings under the work zones. In general, one end of the first segment of one of the boxes was placed on the support and held temporarily in position by a crane (Figure 6). Next the second segment, running to the next support, was suspended by a second crane while bolting the joint of the two sections (Figure 7).

Figure 7. Girder erection – segment 2

Then the last girder was erected and the braces between the two girders were installed. This operation was repeated until the structure in axis 1 was erected completely.

CONCLUSIONS

This project's major challenge was to conduct a more exhaustive search to accumulate information on the standards, requirements, common practices and the latest worldwide research and development concerning the construction, behaviour and design of horizontally curved steel box girders.

The success of this project is attributed in part to the excellent cooperation and assistance of the steel structure fabricator from the beginning of the project, understanding of the erection methods and the knowledge gained regarding the difficulties encountered in the performance of similar projects.

The bridge is scheduled to be opened to traffic in the summer of 2011.

Nikolay Velev is a Senior Engineer, Engineering Division, Transportation Operations Centre for the engineering firm Dessau Inc. in Montréal. After about ten years in construction, he has worked in the bridge field since 2006.

List of stakeholders	Summary of bridge characteristics
Client: Ministère des Transports du Québec	Total length: 227 m
General Contractor: Simard-Beaudry Construction	Radius of curvature: 120 m
Engineer: Dessau Inc.	Structure: two steel box girders
Interchange Designer: Genivar / CIMA+ / Dessau Consortium	Spans: 3 / 49 m – 52 m – 36 m
Steel Fabricator: Structal-ponts – Div. of Canam Group Inc.	Steel weight: 543 t
Steelwork Erector: Montacier International	

NEWS & EVENTS

CISC TECHNICAL FORUM – NEW –

To further advance the growth and sharing of knowledge gained in steel design and construction, CISC launches the CISC Technical Forum: http://forum.cisc-icca.ca.

CISC invites you to visit the Forum and register as a Forum member. You may then view the full content, start a thread on matters related to steel construction, post a question, discuss challenging matters with other participants and specialists and post images of your projects, etc.

The views expressed in the Forum are those of the author. CISC administers the Forum and assumes the role of the moderator.

CISC SSEF ANNUAL CONVENTION

CISC's 81st and SSEF's 25th Annual Convention will be held from June 8 to 11, 2011, in the scenic area of Mont Tremblant, Quebec! 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 will be 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, including The Incredible Economic, Social and Environmental Future of the Arctic and Where in the World is the Canadian Market? There will also be a variety of other interesting topics for discussion. Let's not forget the Golf Tournament and many other entertaining activities throughout the convention.

Also this year, we celebrate our first Peoples' Awards Night, recognizing lifetime achievements! This event will be a great evening of entertainment that also offers attendees the opportunity to network with old colleagues, while making new contacts. The Awards Gala will be held on Friday night this year, with the convention wrapping up on Saturday afternoon.

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

CODES AND STANDARDS NEWS

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 2005 Str. Comm.	NBC 2010 Str. Comm.	late 2011
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 S6S1-10	S6S2-11	2011
CSA S6.1 Commentary on Canadian Highway Bridge Design Code	CSA S6.1-06	S6.1-14	2014
- Supplements to CSA S6.1	CSA S6.1S1-10	S6.1S2-11	2011
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]	G40.20-12 G40.21-12	2012
CSA W59 Welded Steel Construction (Metal Arc Welding)	CSA W59-03 (R2008)[3]	W59-11	2011
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	S136-13	2013
- Supplements to CSA S136	CSA S136S1-09	S136S2-11	2011
CSA S136.1 Commentary on CSA S136	CSA S136.1-07	S136.1-13	2013

[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*

CONTINUING EDUCATION COURSES

At CISC, we draw on the skills of leading designers, researchers, steel fabricators and industry experts to develop and deliver our courses.

Along with our ongoing calendar of courses, we are pleased to present four new courses in 2011, Seismic Connections for Steel-Framed Buildings, Connections I for Steel Detailers, Nouveautés de CSA S16-09 et découverte du Handbook and Assemblages pour structures en acier, plus three significantly updated and enhanced courses, Steel Bridges – Design, Fabrication, Construction, Seismic Design of Steel-Framed Buildings and Conception, fabrication et construction de ponts en acier.

For full course information, online registration and the latest updates please visit our website www.cisc-icca.ca/courses.

Steel Bridges – Design, Fabrication, Construction – New Course
This course covers the design, fabrication and construction of steel bridges based on the 2010 Canadian Highway Bridge Design Code. The practical and economical aspects of fabrication, erection, choice of material and their impact on design will also be emphasized. The presentation and the Course Notes include four design examples illustrating extensive design calculations for I-girders and box girders of straight and curved configurations. Topics receiving greater emphasis in 2011 include fatigue and brittle fracture, integral abutments, aesthetics and sustainability.

Course leaders for the English language edition are Gilbert Grondin, Ph.D., P.Eng., Professor of Civil Engineering, University of Alberta; James Montgomery, Ph.D., P.Eng., LEED® AP, Principal, DIALOG; and Paul J. King, P.Eng., VP Engineering, Rapid-Span Structures Ltd. The course schedule is as follows:

St. John's, NF	Oct. 4 & 5
Moncton, NB	Oct. 6 & 7
Toronto, ON	Oct. 31, Nov. 1
Calgary, AB	Nov. 29 & 30
Victoria, BC	Dec. 1 & 2

Course leaders for the French language edition are Gilbert Grondin, Ph.D., P.Eng., Professeur de génie civil, Université de l'Alberta; Jean de Gaspé Lizotte, M.Sc., ing., Directeur, Projets spéciaux, Dessau Soprin inc.; and Richard B. Vincent, B.Eng., ing., Vice-président, recherche, Groupe Canam Inc. The course schedule is as follows:

Montréal	8 et 9 nov
Québec	10 et 11 nov

CSA S16-09 Changes & Steel Handbook Highlights
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 live sessions. Participants can register for the first session titled "CSA S16-09 Changes" or all four sessions. In addition, discounted bundles with the CISC Handbook and CISC Membership are available.

The first session covers the major changes and new provisions introduced in CSA Standard S16-09, "Design of Steel Structures" and the CISC Commentary on CSA S16, including Clause 27 Seismic design. A brief overview of the Handbook is also included.

The intent of the next three sessions, titled "Steel Handbook Highlights," is to provide understanding on the background and use of design aids contained in the Handbook while drawing the participants' attention to changes, new additions and hidden gems. The presenters use numerous design examples to illustrate design aids for simple connections (single angle, double angle, end plate and shear tab), tension members, compression members and flexural members (composite and non-composite).

The English language course leaders are David H. MacKinnon, M.A.Sc., P.Eng., Director of Training, CISC; and Charles Albert, M.Sc.E., P.Eng., Manager of Technical Publications, CISC. The webinar schedule is as follows:

September 14 & 15	10:00 a.m. & 1:00 p.m. EDT
December 5 - 8	12:00 p.m. EST

The French language course leaders are Sylvie Boulanger, Ph.D., ing., Directrice, ICCA-Québec; and Charles Albert, M.Sc.E., P. Eng., Directeur des publications techniques, ICCA. The webinar schedule is as follows:

21 et 22 septembre	10 h et 13 h (HNE)

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: the identification of 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
Calgary, AB	September 28
Vancouver, BC	September 29

Connections I for Steel Detailers
This 40-hour online course is the first level in a two level series intended to develop the skills necessary for the design of steel connections as related to the construction of steel-framed

structures. It is presented in 20 two-hour live sessions, two nights a week. The basic objective is to assist steel industry personnel in their understanding of basic connection design principles, and to design simple welded and bolted connections suitable for fabrication. Participants will also understand the origin of the rules and standards used in the steel industry.

The learning goals of this course are to understand and apply the major principles of the static forces and strength of materials in connection design, recognize the properties and characteristics of steel, use the appropriate connecting elements (bolts and welds), develop curiosity and critical judgment. Topics include properties of steel, high strength bolts, welds, tension members, bolted shear connections and welded shear connections.

The course leader is Marc Robitaille, M.Sc.A., P.Eng., Vice-President Engineering, Supermétal Structures Inc. The webinar schedule is as follows:

Tuesdays and Thursdays, 7:00 p.m. to 9:00 p.m. (ET)
October 4 to December 8

Seismic Design of Steel-framed Buildings
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.

Calgary, AB	October 17
Vancouver, BC	October 19
Fredericton, NB	November 7
Halifax, NS	November 9
Toronto, ON	November 21
Ottawa, ON	November 23

Seismic Connections for Steel-Framed Buildings
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 Seismic Design course and Seismic Connections course are offered back-to-back in each location. The schedule is as follows:

Calgary, AB	October 17 & 18
Vancouver, BC	October 19 & 20
Fredericton, NB	November 7 & 8
Halifax, NS	November 9 & 10
Toronto, ON	November 21 & 22
Ottawa, ON	November 23 & 24

Inspection of Steel Structures
This course will prepare designers, building officials and other specialists for the inspection of steel-framed buildings in the fabrication shop and the field. It is presented online in four two-hour live sessions over one or two days. Applicable sections of the National Building Code of Canada, CSA S16 plus referenced material, product and quality standards, CISC Code of Practice and CISC Certification guidelines will be addressed. Typical structural design, erection and shop drawings for steel-framed buildings will be explained. Material identification, tolerances, seismic connections, bolting and welding processes and procedures will be reviewed.

The course leader is Robert E. Shaw, Jr., PE, President, Steel Structures Technology Center, Inc. Please check the Education page of our website (www.cisc-icca.ca/courses) for dates and locations.

NEW MEMBERS

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

Fabricator
CC Industries (C&C Pneumatics Inc.)
#1 – 820E 51st Street E, Saskatoon, SK

Arkbro Structures (A division of Arkbro Industries)
889 Pantera Drive, Unit 1, Mississauga, ON

Eascan Building Systems Ltd.
442 Queen Street, Truro, NS

GAR-DON Steel Industries Ltd.
1308 – 8 Street, Nisku, AB

Detailer
IKONA Drafting Services Inc.
1125 Pettigrew Avenue, Regina SK

Service Centre
Samuel, Son & Co. Limited
2360 Dixie Rd., Mississauga, ON

Supplier
Marmon/Keystone
290 Chemin du Tremblay, Boucherville, QC

Akhurst Machinery
9615 – 63 Avenue, Edmonton, AB

Voortman USA Corporation
450 South Sprue St. Unit F, Manteno IL

Medallion Pipe Supply Company
821-45th Street East, Saskatoon, SK

Provincial Galvanizing Ltd.
874-57 St. E, Saskatoon, SK

Blastman Coatings Ltd.
353 Clarence Street, Brampton, ON

EVENTS

ASCE/AISC Student Bridge Competition
May 20 – 21, 2011 Texas A&M University, U.S.A.
www.aisc.org/content.aspx?id=780

2011 CISC / SSEF Annual Convention
June 8 – 11, 2011 Mont Tremblant, Quebéc
www.cisc-icca.ca/agm

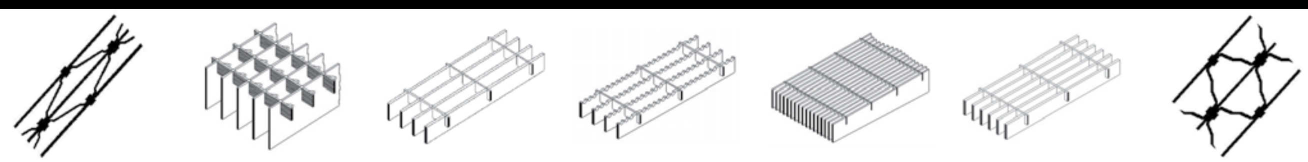
Steel Day
September 23, 2011
Various locations across Canada
www.steelday.ca

CWA Annual Conference
September 19 – 20, Banff, Alberta
www.cwaconference.org

REGIONAL ACTIVITIES

Congratulations to Merv Cooper!
Merv Cooper of Supreme Steel Bridge Division is celebrating 50 years in the steel business and will be retiring at the end of the year!

Thanks to Mike Payne!
Mike started his career at Richard Wilcox Overhead Crane. Through the years, he was with Vic West in Regina before moving to Edmonton and working at Scott Steel and then Waiward Steel where he was Project Manager and Senior Estimator. Recently Mike has been the CISC Western Regional Manager. All the best in your retirement Mike!



Legend:
*sales office only
B - buildings
Br - bridges
S - structural
P - Platework
J - open-web steel joist

ATLANTIC

Canam–Canada
Moncton, NB 506 857 3164
www.canam.ws

Cherubini Metal Works Limited S, P
Dartmouth, NS 902 468 5630
www.cherubinigroup.com

Eascan Building Systems Ltd.
Truro, NS 902 897 9553
www.eascan.ca

MacDougall Steel Erectors Inc. S
Cornwall, PE 902 855 2100
www.macdougallsteel.com

Marid Industries Limited S
Windsor Junction, NS 902 860 1138
www.marid.ns.ca

MQM Quality Manufacturing Ltd. S, P
Tracadie–Sheila, NB 506 395 7777
www.mqm.ca

Ocean Steel & Construction Ltd. S, P
Saint John, NB 506 632 2600
www.oceansteel.com

Prebilt Structures Ltd. S, P
Charlottetown, PE 902 892 8577
www.prebiltsteel.com

RKO Steel Limited S, P
Halifax, NS 902 468 1322
www.rkosteel.com

Tek Steel Ltd. S
Fredericton, NB 506 452 1949

QUÉBEC

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

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

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

Acier Trimax Inc. S
Ste-Marie de Beauce, QC 418 387 7798
www.trimaxsteel.com

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

B.K. Fer Ouvré S
St-Bruno, QC 450 441 5484
www.bkiron.com

Canam–Canada S, J
Ville de St-Georges, QC 418 228 8031
www.canam.ws

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

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

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

Industries Canatal Inc. S
Thetford Mines, QC 418 338 6044
www.canatal.net

Lainco Inc. B, Br, S
Terrebonne, QC 450 965 6010

Les Aciers Fax inc B, S
Charlesbourg, QC 418 841 7771

Les Constructions Beauce–Atlas Inc. S
Ste–Marie de Beauce, QC 418 387 4872
www.beauceatlas.ca

Les Industries V.M. Inc. S
Longueuil, QC 450 651 4901

Les Métaux Feral Inc. S
St-Jérôme, QC 450 436 8353

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

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

Métal Moro inc S
Montmagny, QC 418 248 1018

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

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

Nico Métal inc. S
Trois-Rivières, QC 819 375 6426
www.nico–metal.com

Poutrelles Delta Inc. J
Ste-Marie, Beauce, QC 418 387 6611
www.deltajoists.com

Produits Métalliques PMI S
Rimouski, QC 418 723 2610
www.pmibuilding.com
Batiment modulairs et structures d'acier

Quéro Métal Inc. S
St. Romuald, QC 418 839 0969
www.querometal.com

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

Ray Metal Joliette Ltée S
Joliette, QC 450 753 4228

Structal – Bridges, A Division of Canam Group Inc. S, P
Québec, QC 418 683 2561
www.structalponts.ws

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

Sturo Metal Inc. S
Levis, QC 418 833 2107
www.sturometal.com

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

Tardif Metal Inc. B, S, P
Lac St-Charles, QC 418 849 6919
www.sm–inc.com

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

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

Arkbro Structures S
Mississauga, ON 905 766 4038
www.arkbrostructures.com

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

Azimuth Three Enterprises Inc. S
Brampton, ON 905 793 7793

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

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

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

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

Canam Canada – A division of Canam Group inc. (Mississauga) S, J
Mississauga, ON 905 671 3460
www.canam.ws

Central Welding & Iron Works Group S, P
North Bay, ON 705 474 0350
www.central–welding.com

Cooksville Steel Limited S
Kitchener, ON 519 893 7646
www.cooksvillesteel.com

Cooksville Steel Limited S
Mississauga, ON 905 277 9538
www.cooksvillesteel.com

D & M Steel Ltd. S
Newmarket, ON 905 936 6612

Eagle Bridge Inc. S
Kitchener, ON 519 743 4353

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

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

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

Gorf Contracting Limited S, P
Schumacher, ON 705 235 3278
www.gorfcontracting.net

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

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

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

Linesteel (1973) Limited B, S
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Brampton, ON 905 458 8850
www.lorvinsteel.com

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

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

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

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

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

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www.miragesteel.com

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www.noraksteel.com

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Orillia, ON 705 326 3619
www.norweld.com

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www.paramountsteel.com

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www.pittsburghsteel.com

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www.quadsteel.ca

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www.refacindustrial.com

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www.shannonsteel.com

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www.spencersteel.com

Steel 2000 Inc. S
Chelmsford, ON 705 855 0803

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Guelph, ON 519 837 1973
www.telcosteelworks.ca

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www.towersteel.com

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www.tresmansteel.com

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www.waltersinc.com

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ww.ccindustries.ca

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www.capitolsteel.ca

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Thunder Bay, ON 807 623 4844
www.coastalsteel.ca

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Saskatoon, SK 306 931 4412
www.elancesteel.com

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Winnipeg, MB 204 589 7371
www.empireiron.com

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www.iwlsteel.com

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Saskatoon, SK 306 242 0884
www.jnewelding.com

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www.shopost.com

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www.supremesteel.com

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Saskatoon, SK 306 955 4425
www.weldfab.com

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www.aaasteel.com

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www.angliasteel.ca

Bow Ridge Steel Fabricating S
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www.cwcarry.com

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www.canam.ws

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Collins Industries Ltd. S
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www.collins-industries-ltd.com

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www.empireiron.com

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www.eskimosteel.com

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www.gardon.ca

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www.jvdriver.com
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www.ledersteel.com

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www.moli.ca

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www.northern–weldarc.com

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www.omegajoists.com

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www.precisionsteel.ab.ca

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www.rampartsteel.com

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Edmonton, AB 780 435 3807

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www.supermetal.com

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www.supremesteel.com

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www.supremesteel.com

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www.trianglesteel.com

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www.tsesteel.com

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Nisku, AB 780 955 7671
www.wfwelding.com

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www.waiward.com

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www.whitemudgroup.ca

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www.barnonemetals.com

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www.canam.ws

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www.supremesteel.com

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www.empireiron.com

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www.geothird.com

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ISM Industrial Steel & Manufacturing Inc. B, Br, S, P
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www.ismbc.ca

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www.jpmetalmasters.com

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www.m3steel.com

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www.macform.org

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www.rapidspan.com

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www.solidrocksteel.com

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www.warnaarsteel.com

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www.wesbridge.com

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www.bld.ca

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www.bdsd.com

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www.structuredca.com

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www.genifab.com

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www.steeldetailers.com

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www.kgsgroup.com

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www.steltec.ca

Les Dessins Trusquin Inc. B, Br
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www.datadraft.com

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www.mddrafting.com

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www.mddrafting.com

M & D Management Consulting Ltd. B
Parksville, BC 250 248 4871
www.detaileddesign.com

M-Tec Drafting Services Inc. B, Br, P
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www.mtecdrafting.com

ProDraft Inc. B, Br, P
Surrey, BC 604 589 6425
www.prodraftinc.com

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www.ranmartech.com

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www.rivercitydetailers.com

Saturn Detailing Services Ltd. B
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www.sde-draft.com

Summyx inc. Br, S
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www.summyx.com

TDS Industrial Services Ltd. B, P
Pitt Meadows, BC 640 465 6085
www.tdsindustrial.com

Techdess Inc. B
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Tenca Steel Detailing Inc. Br
Charlesbourg, QC 418 634 5225
www.tencainc.com

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Angus, ON 705 424 1956

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www.montacier.com

Montage D'Acier International Inc. Br, P
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Acier CMC, division de Crawford Metal Corp.
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www.acierpicard.com

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www.bending.net
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www.agtech.qc.ca

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Brampton, ON 905 799 7535
www.agwaymetals.com

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Edmonton, AB 780 435 3936
www.akhurst.com

All Fabrication Machinery Ltd.
Leduc, AB 780 980 9661
www.allfabmachinery.com
Steel and plate fabrication – machinery

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www.amcanjumax.com
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Abrasive blasting, glass bead

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Beeton, ON 905 729 2229
www.bordengratings.com
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Brunswick Steel
Winnipeg, MB 204 224 1472
www.brunswicksteel.com
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www.corrcoat.ca
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www.customplate.net
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www.devoecoatings.com
Coating, paint

DryTec Trans–Canada
Terrebonne, QC 450 965 0200
www.drytec.ca
Grating, metallizing, paint

EBCO Metal Finishing L.P.
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Fisher & Ludlow, A Division of Harris Steel Limited
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www.globec – machinery.com

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IKG Industries
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www.ikgindustries.com

J & M Sandblasting & Painting
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www.midwaywheelabrating.com
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Brampton, ON 905 840 9872
www.moorebrothers.ca

Pacific Bolt Manufacturing Ltd.
New Westminster, BC 604 524 2658
www.pacbolt.com
Steel fasteners, structural bolts, anchor bolts, tie rods

Peinture Internationale (une division de Akzo Nobel Peintures Ltée)
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www.international-coatings.com
Protective coatings, corrosion-resistant paints

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Reliable Tube Inc.
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www.reliabletube.com
Hollow Structural Steel Tube

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www.consortech.com
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www.terraprobe.ca
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www.tri-kretecoatings.com
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Tuyaux et Matériel de Fondation Ltée
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VARSTEEL Ltd.
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Steel metal floor/roof deck, wall and roof cladding

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www.vortmancorp.com

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www.waxmanindustrial.ca

Western Industrial Services Ltd. (WISL)
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www.wisl.ca
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Buffalo, NY 519 536 1114

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Burlington, ON 905 331 3400
www.essarsteelalgoma.com

Calgary, AB 403 263 4102
www.essarsteelalgoma.com

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