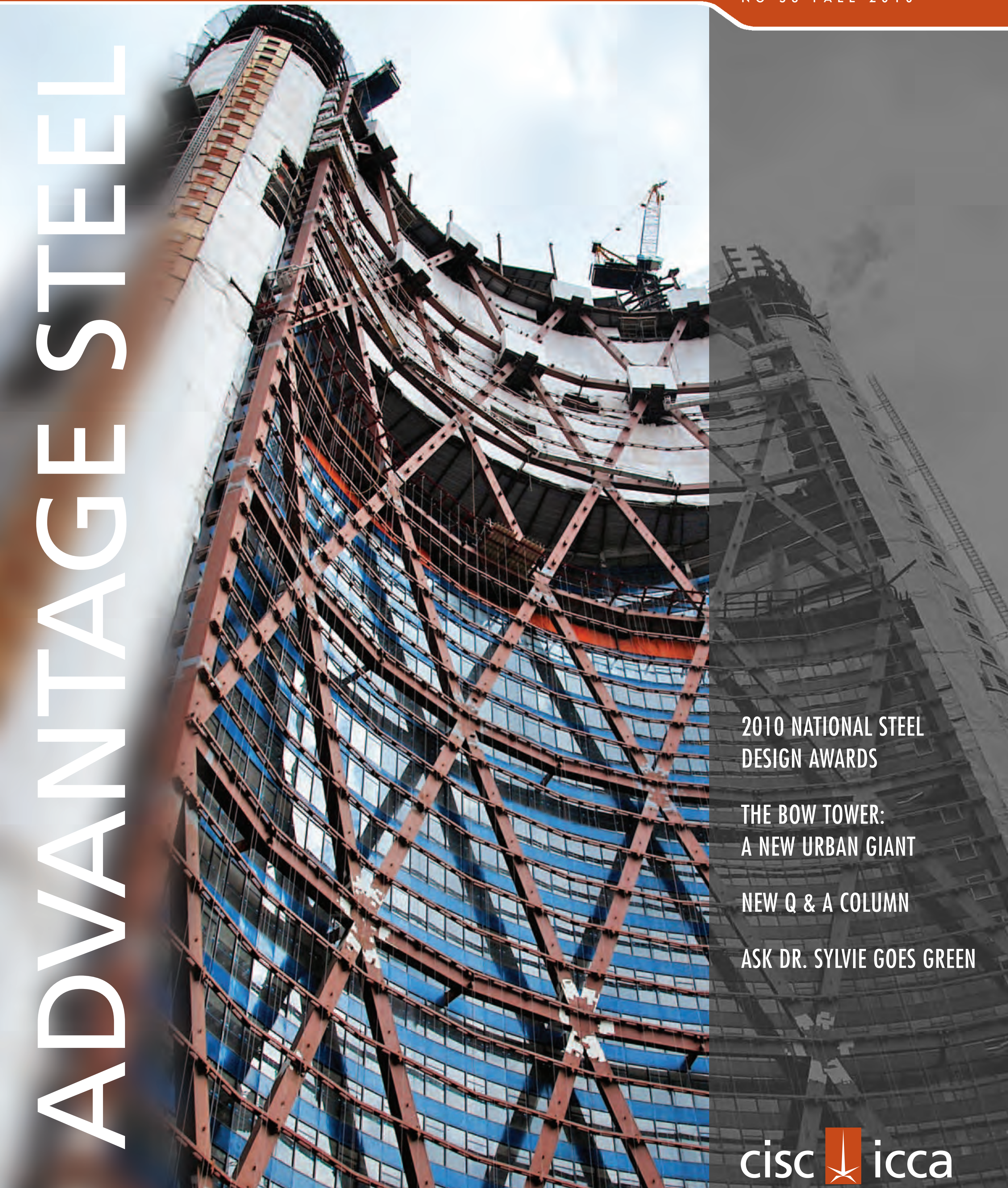
NO 38 FALL 2010

ADVANTAGE STEEL



2010 NATIONAL STEEL DESIGN AWARDS

THE BOW TOWER: A NEW URBAN GIANT

NEW Q & A COLUMN

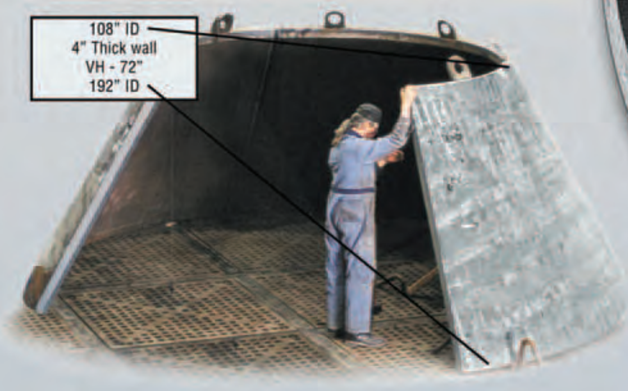
ASK DR. SYLVIE GOES GREEN

cisc icca

CANADIAN INSTITUTE OF STEEL CONSTRUCTION

Hodgson Custom Rolling Inc.

services a wide variety of industries in the ENERGY SECTORS of hydro, petro chemical, atomic, gas, oil, wind, etc. in addition to those in heavy manufacturing, steel, pulp & paper, mining, marine, forestry, etc. Hodgson's commitment to providing customers superior products and personalized professional service has earned itself a reputation for excellence, making the name HODGSON synonymous with "paramount quality and workmanship".



Hodgson Custom Rolling Inc. is one of North America's largest plate rolling, forming, section rolling and fabricating companies

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HODGSON CAN HELP SOLVE YOUR PROBLEMS

FROM THE PRESIDENT

THE CISC GIVES YOU THE ADVANTAGE

The Canadian Institute of Steel Construction (CISC) provides the Canadian design community with project assistance on steel framing solutions. Through its Project Analysis Division (PAD), architects, engineers, owners, and developers can call upon the CISC, at no charge, for assistance in providing innovative framing solutions unique to their project along with cost estimates. Through this CISC assistance, project teams are better able to make the right choice that is best suited for their project.

Steel provides the advantage of extreme accuracy, high quality, fastest erection, high LEED points, light weight, long spanning, ductility, flexibility, and its ability to take on any shape. All of these traits make steel the framing choice for the most beautiful, complex, and challenging buildings and bridges in the world.

Recent national and international advances in materials, designs, products and steel framing solutions are now available to solve all the challenges faced by the Canadian design community.

Knowledge of these recent technologies is not well known or understood. As an example, framing systems such as *Staggered Truss*, *Girder Slab*, and *Slim Floor*, to name a few, now solve local height restrictions challenges in some cities and provide a steel alternative to high rise residential construction.

The CISC is committed to providing the design community with the latest steel design solutions available. Contact us and get your advantage from steel.

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 enquire 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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COVER PHOTO: The Bow Building, Calgary, AB| *Photo: Terri Meyer Boake*

PHOTO ON THIS PAGE: Legendre Garage and Body Shop, Montreal, QC, A National Design Award, Sustainability Recipient | *Photo: Jean-Guy Lambert / Provencher Roy + Assoc. Arch.*

Q & A

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: CSA Standard S6, Canadian Highway Bridge Design Code, requires that cross-frame connection plates be connected to the flanges of bridge girders. The bolted detail, as shown (in Figure 1), appears to be quite popular in rehabilitation work. I heard that this bolted detail qualifies for a "Category B" fatigue detail, but it is not clear to me how simply bolting the stiffener to the bottom flange makes things better because the web weld is still present.

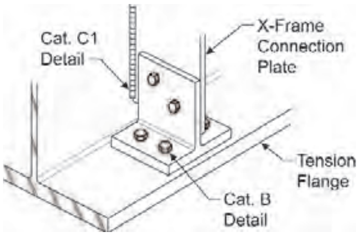


Figure 1

ANSWER: Where the stiffener also serves as a cross-frame connection plate, both distortion-induced fatigue and load-induced fatigue should be considered. The bolted detail as shown does not alter the stiffener-to-web welded fatigue detail with respect to load-induced fatigue because this welded detail remains "Category C1". However, connecting the connection plate to the flanges (when done correctly) should improve the distortion-induced fatigue resistance substantially.

In order to avoid welded attachments in the tension flange, many older welded steel bridge girders feature cross-frame connection plates that were either cut short from, or ground to bear on, the tension flange. This outdated practice inadvertently resulted in the web taking out-of-plane stresses due to relative displacements of adjacent girders. These stress ranges, typically unaccounted for in the analyses, have been identified as the common cause of distortion-induced fatigue damage to welded bridge girders. Recent editions of CSA S6 require that cross-frames and diaphragms be connected to each flange for a minimum force of 90 kN.

QUESTION 2: CISC/CPMA Standard 1-73a versus CISC/CPMA Standard 2-75: What do they have in common and what are the major differences?

ANSWER: These standards provide essentially the same laboratory requirements. The provision for surface preparation reflects the key difference. In addition to removal of grease and oil in accordance with SSPC Standard SP1, CISC/CPMA 2-75 requires steel cleaning in accordance with SSPC SP7, Brush-Off Blast Cleaning. Where CISC/CPMA 2-75 serves as a primer, it should be compatible with the top coat. CISC/CPMA 1-73a is a standard for one-coat paint, not a standard for primer.

Question 3: I have noticed that twist-off bolts are gaining popularity. Are they accepted as high-strength bolts for structural applications? If they are, what are the shear and tensile resistances?

Figure 2

ANSWER: ASTM F1852, twist-off type tension-control structural bolt/nut/washer assemblies, are used increasingly in pre-tensioned connections. These bolts feature a splined end which, when properly installed with a special wrench, should shear off when the target pretension is reached (See Figure 2).

ASTM F1852 and F2280 bolts have mechanical and chemical properties equivalent to A325 and A490 high-strength bolts, respectively. Specific design requirements can be found in CSA Standard S16-09 Clauses 22.2.5 and 23.8.4 and in Table 3.

The tabulated values for ultimate shear resistance in bearing-type connections and tensile resistances of A325 and A490 bolts in Part 3 of the CISC Handbook of Steel Construction may be used for F1852 and F2280 bolts, respectively, whereas smaller values for the 5% slip coefficients, c1, are specified in Table 3 of S16-09 for use of twist-off bolts in slip-critical connections.

Because surface friction is an important factor during installation, these bolt assemblies include hardened washers. Also, the use of tension-control bolts calls for prior testing and particular attention to their handling and storage so as to avoid lubricant deterioration over time.

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

SEISMIC CORNER
DUCTILE STEEL PLATE WALLS WITH OPENINGS

Alfred F Wong, P.Eng.

Many changes and new provisions have been incorporated in the seismic design clauses of CSA Standard S16-09. This article highlights the provisions for two new features introduced for the plate wall systems.

Experimental and analytical studies conducted at the University of Alberta since the early 80's have demonstrated that well-proportioned *plate walls* behave very well when subjected to wind or seismic loads. Design provisions for *plate walls* incorporated in previous editions of S16 were primarily based on the outcome of these studies. These provisions recognize tension-field action for infill plate without opening.

WALLS WITH LARGE OPENINGS

More recent experimental and analytical studies carried out at University of New York in Buffalo have led to changes and new provisions for the design of *plate walls* as seismic-force-resisting systems in S16, including the provisions for wall openings. Clause 27.9.2.4 of S16-09 permits an opening at each of the upper corners of infill plate panels by cutting out a quadrant with a radius not exceeding one-third of the clear height of the plate panel, as shown in Figure 1. These openings are large enough to accommodate the passage of heating/cooling ducts in many situations.

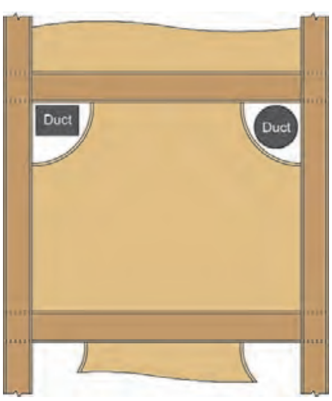


Figure 1 - Plate wall with large reinforced openings

A reinforcing arched plate is welded to the cut edge and the boundary members. This arch must be adequately proportioned and connected to permit the development tension-field action. Secondary effects corresponding to total design storey drift should also be accounted for. CISC Commentary on Clause 27.9.2 of S16-09 provides further explanation on the subject.

Shear walls are usually located around service cores and riser shafts where the horizontal distributions of heating/cooling and other mechanical and electrical services must penetrate some of these walls. The provision for these large wall openings enhances the adaptability of steel plate walls in many applications.

WALLS WITH PERFORATED PLATE PANELS

Research studies at University of New York in Buffalo have also demonstrated that infill plates with circular perforations that are uniformly distributed in a defined configuration (Figure 2) also perform well. Clause 27.9.2.3 defines the geometric requirements and restrictions for these round holes and provides the formula for calculating the shear resistance of the plate panels. The reduced stiffness due to the perforations can be determined using the effective thickness method given in the Commentary on the clause.

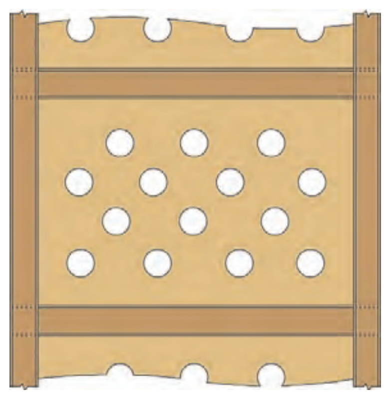
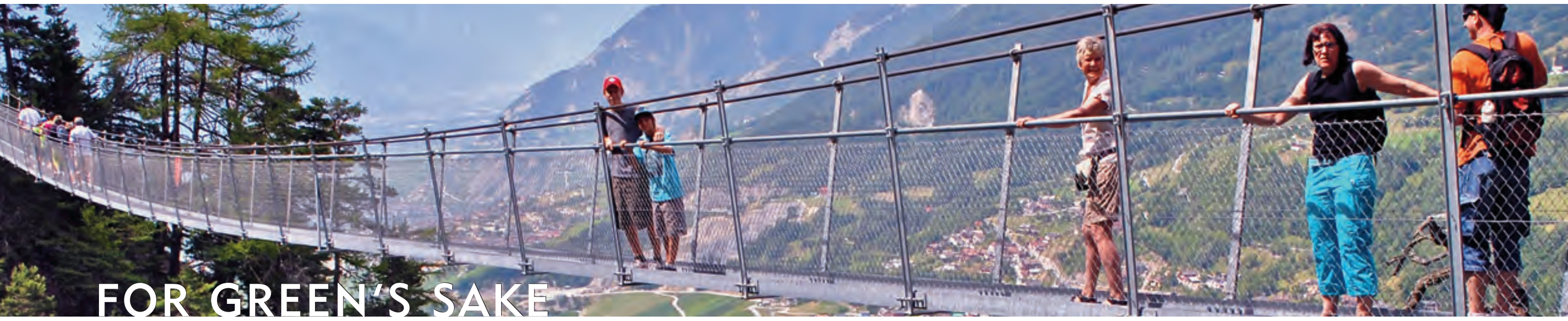


Figure 2 Plate wall with perforated infill plate

Often handling for erection and fabrication purposes, instead of seismic forces, dictates the minimum infill plate thickness. In those cases, the plate thickness increase inflates the capacity design forces, including design forces for columns, beams, connections, foundation and possibly diaphragms. The provision for plate perforations in accordance with Clause 27.9.2.3 helps to alleviate this unnecessary increase of capacity design forces and member sizes.



FOR GREEN'S SAKE

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, reusable, 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 deals with recycled content, regional material and reuse in the context of the new LEED version.

RECYCLED CONTENT AND BEYOND

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

As Manager of Sustainability for CISC, I receive a (high) number of questions on the new LEED 2009 calculations for recycled content, regional materials and reuse. Some clarifications follow. Should you have additional questions, please do not hesitate to contact me at sboulanger@cisc-icca.ca.

What is the first attribute that comes to mind when thinking about steel and sustainability? Most people will answer the high recycled content of steel. Understandably so as the steel components generally average 60% recycled content in a commercial or institutional type building. How does one arrive at that value? It is really from a combination of two processes: the EAF (Electric Arc Furnace) and the BOF (Basic Oxygen Furnace). Shapes (W shapes, channels) tend to be produced via the EAF route. In fact, in North America, all W shapes are the result of the EAF process which represent approximately 90% recycled content. The BOF process, for steel decks and tubular sections, uses about 25%, up to 35% recycled content to produce. More than half of the weight of construction products in a project comes from the EAF process resulting in the average mentioned above. This brings me to the following question.

Should steel be specified by recycled content in a contract document to improve the sustainability rating of a building? No. Definitely not a good idea. Recycled content is a driver to encourage recycling of materials, which would otherwise be disposed of. However, it is not a suitable driver for metals that are already recovered and recycled close to their maximum. Specifying recycled content for steel in particular, to obtain a LEED point does not have any beneficial environmental effect. Instead, it can distort the market and result in unnecessary transport costs and emissions. All steel is recyclable and will be multicycled many times without any artificial stimulus and without loss of quality, ad infinitum.

LEED 2009 TIP - THE RECYCLED CONTENT THRESHOLDS ARE NOW 10% (VS 7.5%) TO GET THE FIRST POINT, AND 20% (VS 15%) FOR THE SECOND POINT.

Why is it more difficult to obtain the recycled content of steel for HSS (Hollow Structural Sections)? Because the HSS manufacturer is not the steel producer, hence, it is a two-step process. First, you need to know who the HSS manufacturer is, then, the manufacturer needs to go back to the steel mill who produced the coil used to cold-form the HSS. However, as of Summer 2010, a major tube manufacturer, Atlas Tube, has made it easier for you. From their home page (atlastube.com), you can click directly towards a form (you need heat number or bundle number) to retrace the proper origin and hence, help you do the calculations of recycled content and regional materials for your LEED credits!

What is the easiest way to obtain the values necessary to calculate the LEED regional materials credit? The easy one is the percentage of recycled content (considered raw materials) within an 800 km radius of the mill. The final value will be about 70-80% for the EAF and 15-20% for the BOF. For the BOF, if the mill can document the percentage of iron ore, limestone and/or coal it obtains within an 800 km (by truck) or 2,400 km (by train or boat) radius, then that can be accounted for in the calculation. In general however, mills have not provided easily traceable and well documented information on these raw materials so don't waste too much time on this. However, the recycled content (as raw material) should get you pretty far. Remember that the "value" which gets used in the recycled content calculation includes materials and labor performed on the steel up to the erection of it on site i.e. that means materials + fabrication which amounts to over two thirds of the price of the final steel structure.

LEED 2009 TIP - THE REGIONAL MATERIALS THRESHOLDS ARE NOW 20% (VS 10%) TO GET THE FIRST POINT, AND 30% (VS 20%) FOR THE SECOND POINT. LEED 2009 NOW ALLOWS ANY PERCENTAGE OF REGIONAL MATERIALS, RATHER THAN 80% OR BUST I.E. IF YOU CAN DEMONSTRATE THAT 30% OF RAW MATERIALS ARE WITHIN 800KM OF THE STEEL MILL THEN 30% IS USED. PREVIOUSLY, IF 80% OR MORE OF THE RAW MATERIALS WAS WITHIN AN 800KM RADIUS OF THE MILL AND OF THE SITE, 100% OF THE VALUE COULD BE USED – IF LESS THAN 80%, THEN 0% OF THE VALUE WAS USED.

Can steel be reused with confidence? Yes. The potential reuse of steel is probably the industry's best-kept secret. As a building nears the end of its life, steel can be reused either through the reuse of elements of the original structure for another building project, the reuse of the steel structure in situ (which may include a structural design upgrade) or the dismantling and reuse of the structure at another location. An example is the renovation of Triffo Hall on the University of Alberta campus, which typifies the adage that what was old, is new again. Built primarily of steel in 1915, it is the first project at the University to be registered with LEED. The new design features a two-storey interior "street", that reused and expressed the steel trusses which run the length of the building along the brick wall. Punctures through the second floor allow this "street" to be flooded with natural light. Reusing a steel structure is often easier than one thinks.

LEED 2009 TIP - THERE IS A NEW BOTTOM TIER THRESHOLD (55%) THAT WAS CREATED FOR BUILDING REUSE (WALLS, FLOORS AND ROOF).

Beyond recycled content, steel works well with other materials. It has several attributes that make it a suitable choice for a sustainable solution. So many people like a steel built environment because it is light, open, airy and adaptable. Steel structures mature well with age, rather than deteriorate and decay. Steel's long clear spans mean that interiors can be changed with ease. Steel frames can readily be adapted and reconfigured to give old buildings a new lease on life, economically and efficiently. The longevity of a building is fundamental to its overall sustainability.

Sylvie Boulanger is Manager of Sustainability for the Canadian Institute of Steel Construction (CISC).

*Sources for this article include CISC's website section on Sustainability (**www.cisc-icca.ca/sustainability**), previous issues of Advantage Steel (**www.cisc-icca.ca/advantagesteel**), Corrus' FAQ on Sustainability (**www.corusconstruction.com/en/sustainability/faqs/**) and the CaGBC document "What's new in LEED Canada 2009?" (**www.cagbc.org/database/rte/LEED 2009 Changes.pdf**)*

June 14, 2010, CISC presented the first ever annual National Steel Design Awards. The gala evening was part of the 80th annual general convention which this year was held in beautiful Kananaskis, Alberta. For many years the CISC Regional Steel Design Awards have been a huge success. They gather together owners, developers, architects, engineers, contractors, fabricators, detailers and suppliers in a celebration of steel design excellence. It was high time to draw on these Regional Awards to launch a National Steel Design Awards Program.

"The Canadian Institute of Steel Construction advances steel design and safety, as well as the efficient, economical and sustainable use of structural steel, particularly where steel is integrated with other building materials such as wood, glass and concrete." said Rob Third, Chair of CISC's National Awards Committee. "This National Awards event shares and recognizes steel design and innovation excellence as well as generating awareness of the advantages of steel in construction across Canada, by showcasing the excellent architects and engineers we have in our country."

Projects were entered in the Architecture, Engineering, and Sustainability award categories. All entries have been previously recognized at the Regional level. Nearly 100 projects were narrowed down to a short list of 16 which went before the judging panel. Six of these 16 entries were selected to receive an award by a jury of 6 architecture and engineering design consultants and university professors:

Sylvain Boulanger – Boldwing Continuum Architects
Robert Driver – University of Alberta
Paul Henry – CY Loh & Associates Engineers
Andrew Metten – Bush Bohlman Engineers
Terry Meyer Boake – University of Waterloo
Pieter Sijptes – McGill University

We thank the jury members for their time and dedication and congratulate the design team members of the six award winning projects for the quality of their work and their outstanding use of steel.

ARCHITECTURE

Award of Excellence
Camilla & Peter Dalglish Atrium, Royal Botanical Gardens, Burlington, Ontario


OWNER: Royal Botanical Gardens
ARCHITECT: Diamond + Schmitt Architects Inc.
STRUCTURAL ENGINEER: Halcrow Yolles
PROJECT MANAGER: MHPM Project Managers Inc.
GENERAL CONTRACTOR: Ira McDonald Construction
CISC FABRICATOR AND DETAILER: Central Steel Fabricators Ltd.

The project capitalizes on the intrinsic qualities of steel to enhance the building's design, fulfilling both program requirements and the client's ambition to create a highly transparent space. Structural steel framing allows art and function to merge in order to fulfill design ambitions. Long steel spans result in a glass enclosed building that visually recalls a green house aesthetic.

Award of Merit
The Water Centre, Calgary, Alberta


OWNER: City of Calgary
ARCHITECT: Sturgess Architecture / Manasc Isaac Architects
STRUCTURAL ENGINEER: Read Jones Christoffersen Ltd.
GENERAL CONTRACTOR: Dominion Construction

ENGINEERING

Award of Excellence

Richmond Speed Skating Oval, Richmond, B.C.

OWNER: City of Richmond
ARCHITECT: Cannon Design Project Directors:
MHPM Project managers
STRUCTURAL ENGINEER, ROOF STRUCTURE: Fast + Epp Engineers
STRUCTURAL ENGINEER, BASE STRUCTURE: Glotman Simpson Consulting Engineers
GENERAL CONTRACTOR: Dominion Fairmile Construction
FABRICATOR: George Third & Son Ltd.
STEEL DETAILER: Tru-Line Drafting
CONSTRUCTION ENGINEERING: Somerset Engineering
STEEL ERECTOR: KWH Constructors

The arches for the Olympic Oval are the longest spanning hybrid steel-wood arches in the world. Spanning 100m, the arches are strengthened by a 10mm thick steel blade on the bottom edge, with W150 steel beams and 25mm thick steel plates strengthening the top. The steel beams rise off the pine beetle wood slabs at both ends to create a raised roof and cantilever overhangs.

Award of Merit

Art Gallery of Ontario Transformation, Toronto, Ontario

OWNER: Art Gallery of Ontario
ARCHITECT: Gehry International
STRUCTURAL ENGINEER: Halcrow Yolles
GENERAL CONTRACTOR: Ellis Don Corporation
CISC DETAILER, ERECTOR & FABRICATOR OF MAIN STRUCTURE: Benson Steel Ltd.
CISC FABRICATORS OF STAIR STRUCTURE: Mariani Metal Fabricators Ltd.

SUSTAINABILITY

Award of Excellence

University of Alberta - Triffo Hall, Edmonton, Alberta

OWNER: University of Alberta
ARCHITECT: Johns Group2 Architecture Engineering Ltd.
STRUCTURAL ENGINEER: Read Jones Christoffersen Ltd.
GENERAL CONTRACTOR: Binder Construction Limited

Triffo Hall is an example of the adage "What was old is new again". Undergoing numerous changes since 1915, Triffo Hall was restored back to its original design. It was very important to use the steel and leave it exposed, retaining the steel trusses that supported the roof and clerestory and making them visible by removing the existing ceiling systems.

Award of Merit

Legendre Garage and Body Shop, Montreal, Quebec

OWNER: Montreal Transport Corporation
ARCHITECT: Provencher Roy et Associés architectes
STRUCTURAL ENGINEER: Pasquin St-Jean & Associés Inc.
GENERAL CONTRACTOR: Pomerleau Inc.
CISC STEEL FABRICATOR: Quirion Metal Inc.
CISC STEEL FABRICATOR: Canam Canada
STEEL DETAILER: Genifab Inc.

For more information, please see our press release and our design award archives:

www.cisc-icca.ca/news/2010/6/nationalawards | press release
www.cisc-icca.ca./awards/national/2010 | archives


OUTERSHIELD 71
SUPREME


REBUILDING AMERICA
NUCOR
GRAND OPENING
NUCOR-YAMATO STEEL

(Photo courtesy Terri Meyer Boake)

Figure 1 - General View of the Tower under Construction (as of June 2010)

A NEW URBAN GIANT: THE BOW TOWER

Michael Seica, Ph.D., P.Eng. and David Stevenson, P.Eng.

The 59-storey Bow Tower, located in downtown Calgary, Alberta will become the headquarters of EnCana Corporation. When completed in 2011, at 238 m (780 feet) in height, this unique structural steel tower will be the tallest building in Western Canada and the second-tallest building in the country. Internationally renowned architect Foster + Partners of London, is the design architect for the development, which includes the north tower consisting of over 195,000 sq. meters (2,100,000 sq. feet) of constructed area above grade and 97,000 sq. meters (1,000,000 sq. feet) including 1,375 parking spaces along with the loading dock and services areas, on six levels below grade. The development will be interconnected with adjacent buildings through a series of stunning "plus fifteen" pedestrian bridges.

The owner, H&R REIT, along with development managers, Matthews Development Alberta, have led, in close collaboration with the client, the project since the start of the concept design phase in late 2005. With executive architects, Zeidler Partnership Architects, and international structural engineers Halcrow Yolles, the form and associated details of this unique building project began to solidify through the design development stage in the fall of 2006. At that time all major subcontractors, and the structural steel contractor Supreme-Walters Joint Venture, were brought on board in a "design assist" capacity.

ESTABLISHING THE SHAPE OF THE TOWER AND THE STRUCTURAL SYSTEM

At the outset, EnCana identified several objectives for the development as a whole. These included establishing a distinctive image for their new headquarters, the creation of a "home away from home" ambiance for all those that worked in and visited the development, the introduction of large "sky lobbies" to help promote incidental interaction within the organization and the introduction of landscaping throughout the development, including within the height of the tower itself. In an effort to maximize the number of perimeter offices and to capitalize on the spectacular view of the Rocky Mountains to the south, the final crescent-shaped form of the tower was established. The design of the tower itself pursued sustainable design goals. As a result of the curving bow shape, wind loads were reduced when compared to a rectangular building and, therefore, the economies of the building were improved. Detailed sun studies were then conducted to confirm the precise orientation of the tower on the site in order to maximize the amount of natural daylight within the work environment. Not least, the building would tie into the enclosed "plus fifteen" pedestrian path through the downtown office and retail buildings.

The development of the structural systems and corresponding selection of materials was driven not only by the building geometry and objectives set out by EnCana, but it was through close collaboration between Foster + Partners and Halcrow Yolles, as well as through their collective desire to create a truly iconic building, one in which the structural systems were an integral and natural part of the overall architectural expression that drove the development of the structural systems in the end.

Structural steel was a natural choice given the overall objectives and building requirements as well as the building geometry that had been developed. The high strength of structural steel generally offers advantages to steel over other construction materials in that its use results in smaller vertical load carrying members (allowing for large more open occupied spaces), lighter and shallower floor framing systems (leading to larger column-free areas), greater future flexibility in terms of accommodating revisions in building occupancies, additional loads and tenant improvements.

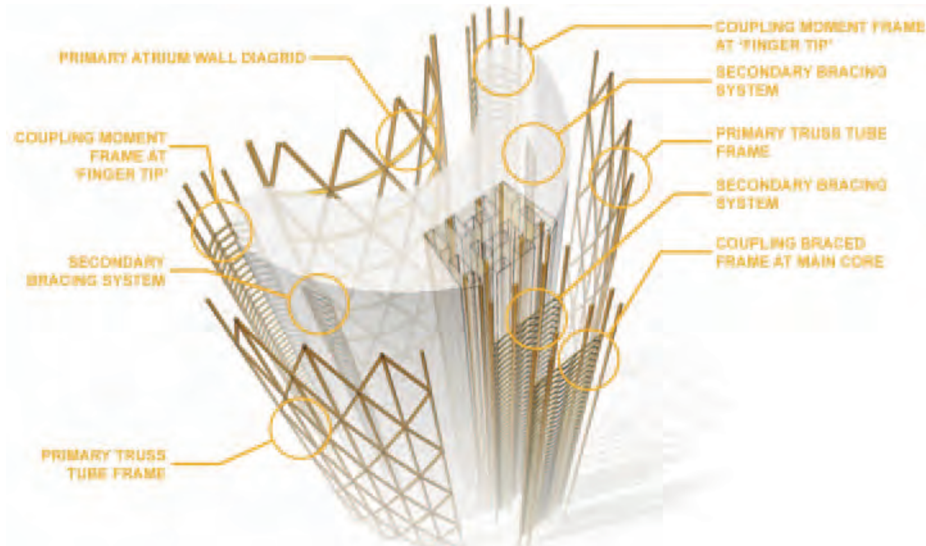


Figure 2 - Exploded View of the Tower

DESIGN OF THE LATERAL SYSTEM

The lateral system, and hence the atrium wall, was designed under wind, seismic and thermal loads – with wind being the governing case. Wind tunnel studies were performed to obtain the wind loads on the tower by creating a 1/400 scale model in a 600-metre radius environment. A separate test was performed on the atrium wall to determine the impact of the wind loads on the long, unsupported atrium wall members. The resulting wind and seismic loads were applied to a finite element model. In total, 180 ultimate limit states (ULS) and 64 serviceability limit states (SLS) load combinations were used.

After considering several different structural solutions, the perimeter "diagrid" or "braced tube" concept was selected as shown in *Figure 2*. A six-storey vertical module was used for the diagrid as it related very well with EnCana's internal space planning requirements. This concept involved three primary braced frames on the curved south elevation and the two northerly facing elevations, "coupled" together with steel moment resisting and braced frames. In addition, and to augment the lateral stiffness of the tower between the six-storey-spaced "nodal floors", a secondary bracing system consisting of conventional steel braced frames at two remote finger core stairs and around the main central elevator core were also provided. As a result, the lateral system consists of the following four principal components:

- At the north-west and north-east sections of the perimeter, six-storey high diagonal grids are facetted along the perimeter.
- The "diagrid" elements are inter-connected through the core with a series of braced frames between the elevators and the north stairs.
- Along the south atrium screen wall face, a similar six-storey modular diagrid spans outside of the atrium and is connected to the bulk of the building by horizontal axial-force members, "drag-struts", at the ends of the atrium.
- The two dominant diagonal grid elements are inter-connected at the ends of the building ("fingertips") with a series of rigid frames.

The gravity load-carrying system of the building consisted of a network of interior columns in a layout that would ensure a depth of the floor beams below 485 mm (19 in), underneath a composite floor slab construction consisting of 75 mm (3 in) concrete cover on 75 mm (3 in) steel deck. High-strength steel – 450 MPa yield stress (65 ksi) – was used for all W-shape gravity columns above level 24 and for the heavy W360 members of the diagrid below level 24.

The deflection criteria considered were a maximum of H/400 at the top of the building, as well as a maximum inter-storey drift of h/350. For seismic loads, the inter-storey building drift was limited to h/40. *Figure 3a* depicts a typical example of the lateral displacement of the building plotted at each storey level for one of the many SLS wind load combinations. The thicker line represents the code-specified limit of H/400 and the inter-storey drift is presented in *Figure 3b*, together with the limiting criterion of h/350. Both values are below the limit. The relative softening above level 54 is due to brace discontinuity.

CHALLENGES AND COMPLEXITIES. UNIQUE ASPECTS

A "top down" construction technique was utilized to construct the majority of the steel ground floor "umbrella". The "top down" construction method enables the superstructure (steel tower) and substructure (parking floors) of a high rise building to be built simultaneously (up and down), thus saving valuable construction time. However, this means that the concrete substructure and perimeter foundation walls below would not be completed until tower erection approaches the 30th floor – a challenge.

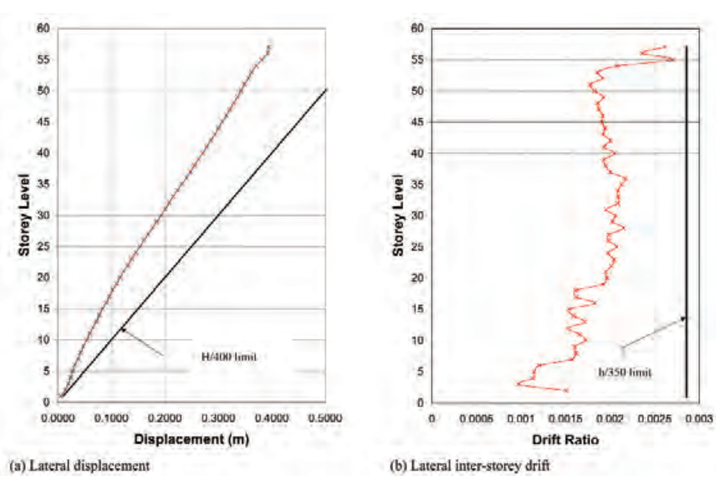


Figure 3 - Lateral Behaviour of the Building (a) Lateral Displacement (b) Lateral Inter-Storey Drift

Figure 4 - Atrium Wall Diagrid Members

Figure 5 - View of the Secondary Steel Attached to the Diagrid Members

Figure 6 - Erection of first 36-tonne node completed in 2009 Atrium Wall Diagrid Members

The majority of the columns supporting the tower above are designed as high 18 m (60 foot) laterally unsupported large diameter concrete-filled steel pipes, ranging from 1200 to 1600 mm (48 to 63 inches) in diameter. To support the below grade parking slabs, stiffened circular steel collar details were developed at the intermediate floor levels. The collars were detailed to accommodate vertical adjustability while allowing coupling of the slabs with the pipe columns.

The detailing of the ground floor structure was complicated even further by the specific design characteristics of the building and construction requirements including the accommodation of the high column uplift forces through through tie-downs.

The stability challenges continued above grade. The complex field-welded details for the diagonal to node connections resulted in the need to "separate" the erection of the tower from the erection of the atrium wall structure, creating a lag of six to 12 floors in some cases. A unique bracing system, coupled with temporary horizontal diaphragm bracing, assisted the permanent structural elements in resisting loads during erection.

Column axial shortening and "super-elevations" were further complicated by the inclined orientation of the diagrid members and the six to 12 floor erection lead of the tower. In the end, very stiff, inclined diagrid members carry less load than the internal gravity columns and, hence, deflect very little. Therefore, it was not necessary to super-elevate the diagrids.

A number of possible atrium wall (i.e. the south wall) structural schemes were considered, each making use of different structural sections: built-up boxes, built-up triangles or large-diameter tubing. In the end, after carefully evaluating all options and based on criteria such as strength considerations, overall lateral system interaction, steel tonnage, erection costs and, not least, visuals, it was decided that the triangular scheme offered superior aesthetics overall, while balancing costs, complexity, ease of construction and impact on the overall structure. Typical diagrid members have sizes up to 1130 x 1320 mm (44.5 x 52 in) with wall thicknesses ranging from 40 to 160 mm (1.6 to 6.3 in). Being architecturally exposed, the triangular section shapes are fireproofed through intumescent coating, a decision based on a custom experimentation programme conducted on various specimens at Underwriters Laboratories Canada. A complex system of secondary steel serving as a curtain wall support system is attached to the diagrid members. Careful attention was paid to the design of this system – design considerations including thermal loads obtained from computational fluid dynamics analyses – and therefore to its connections to the diagonals.

Lastly, one of the major challenges was the design of the connections between the diagrid members, or the "nodes". Having dimensions of approximately 2.8 m (9.2 feet) in width and standing 4.2 m (13.8 feet) tall, the nodes are not only challenging to design but also to fabricate. Welding of thick plate must be done following specific procedures that involve preheating of the elements to be joined before the welding operation is performed. Internal stiffening plates were also employed to better contribute to an efficient transfer of the forces through the node. This obviously added to the complexity of the system and created additional challenges for fabrication. The nodes are fabricated in the shop and then field-welded to the diagonal and horizontal diagrid members.

CONCLUSIONS

The overall requirements, including the building geometry of the unique crescent-shaped Bow Tower and the tight construction schedule, posed several design and construction challenges. Among all the complexities of this novel design, the use of triangular built-up sections had its challenges. In the modern engineering era, when computer-aided design is used extensively, the built-up triangular sections and nodes, as well as their connections, needed to be designed individually. The engineer and the steel fabricator had to go back to first principles in engineering to design these structural elements. When completed, the Bow will represent a key landmark feature that will change the Calgary skyline forever.

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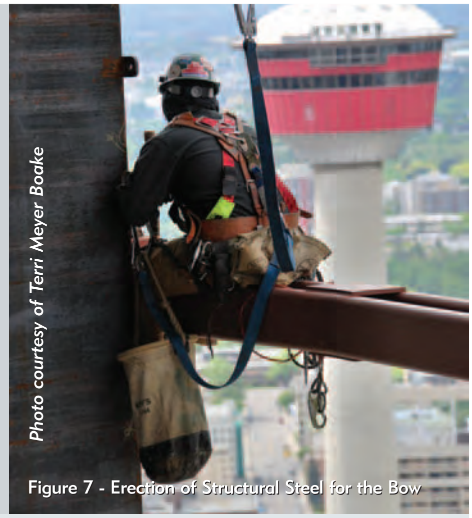

Photo courtesy of Terri Meyer Boake

Figure 7 - Erection of Structural Steel for the Bow

The Bow Project
236 metre height
Start 2007 Completion 2011
58 floors
Six basement floors
157,935 metre square in the tower
39,000 tons of structural steel

OWNER: H+R REIT
DESIGN ARCHITECT: Foster + Partners
EXECUTIVE ARCHITECT: Zeidler Partners
DEVELOPMENT MANAGER: Matthews Development Alberta
GENERAL CONTRACTOR: Ledcor
STRUCTURAL ENGINEER: Halcrow Yolles (Toronto and Calgary)
CISC FABRICATOR: Supreme-Walters Joint Venture

NEWS AND EVENTS

CISC 80th ANNUAL CONVENTION

This past June, CISC hosted their 80th CISC Annual Convention, in the beautiful surroundings of Kananaskis, Alberta. Along in keeping with the 80 year traditions, CISC added some new elements to the assembly for our members. Based on feedback we received from previous meetings, this year marked a first for us, with incorporating more educational forums and seminars on the Thursday and Saturday of the convention.

The conference concluded with the celebration of our first ever National Steel Design Awards, which showcased the regional winners from across Canada and put them up against each other to compete at a National level. See the full results of the awards on page 10.

CORRECTION ON 2009 BC STEEL DESIGN AWARDS

In *Issue 37*, our coverage of the 2009 BC Design Awards was incorrect. We regret and sincerely apologize for this error. The correct awards recipients for the H. A. Krentz and the Engineering Award should have read.

H. A. KRENTZ AWARD

Winner

Vancouver Convention Center

OWNER: PAVCO/VCCEP Ltd.
ARCHITECTS: LMN Architects, Musson Cattell Mackey Partnership, DA Architects + Planners
ENGINEER: Glotman Simpson Consulting Engineers
GENERAL CONTRACTOR: PCL Constructors Westcoast Inc.
STEEL FABRICATOR & ERECTOR: Canron Western Constructors Ltd.
STEEL DETAILER: Dowco Consultants Ltd.

ENGINEERING AWARD

Award of Excellence

Richmond Speed Skating Oval

OWNER: City of Richmond
ARCHITECT: Cannon Design
STRUCTURAL ENGINEER, ROOF STRUCTURE: Fast + Epp Engineers
STRUCTURAL ENGINEER, BASE STRUCTURE: Glotman Simpson Consulting Engineers
PROJECT DIRECTORS: MHPM Project managers
GENERAL CONTRACTOR: Dominion Fairmile Construction
FABRICATOR: George Third & Son Ltd.
STEEL DETAILER: Tru-Line Drafting
CONSTRUCTION ENGINEERING: Somerset Engineering
STEEL ERECTOR: KWH Constructors

NEW PUBLICATIONS

NEW EDITION – AVAILABLE IN NOVEMBER 2010

Limit States Design in Structural Steel, 9th Edition 2010
By G.L. Kulak and G.Y. Grondin

The Ninth Edition reflects changes in CSA Standard S16-09, "Design of Steel Structures", with regard to bolted and welded connections, laterally unsupported beams, block shear and composite beams.

This textbook serves as a comprehensive teaching text for universities and technical colleges, and also as a valuable reference document for practicing engineers. It offers an explanation of the philosophy and practical application of limit states design procedures and provides comments on design requirements contained in S16-09. Divided into 11 chapters, the book covers tension members, flexural members, columns, beam-columns, stability, fatigue behaviour, connections, plate girders, composite construction, and types and grades of structural steel.

CODES AND STANDARDS REVIEW

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 2005	NBC 2010	late 2010
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 S6-06S1 (2010)	S6-06S2	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 S6.1-06S1 (2010)	S6.1-06S2	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]	TBA	TBA
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	S136-15	2015
CSA S136.1 Commentary on CSA S136	CSA S136.1-07	S136.1-15	2015

[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

We have two new courses available this Fall, "Connections for Steel Structures" and "Steel Handbook Highlights".

Connections for Steel Structures – New Course –
The "Connections for Steel Structures" course is the second in a series of three CISC courses on connecting steel components, and a recommended prerequisite for the upcoming CISC course "Design of Seismic Connections in Steel-Framed Buildings".

The "Connections for Steel Structures" course is intended to provide practical guidance to steel designers and clarify the complimentary roles of the fabricator and the design engineer with respect to connection design. Emphasis is placed on connections and their impact on costs and economy.

The basic objective is to assist designers in their understanding of how connections influence member design and vice versa, and to emphasize the importance of considering both connections and member selection for optimum economy. The scope of the course is limited to connections normally encountered in common types of steel building structures.

The participant will come away with an understanding of connection behaviour, the behaviour of bolted and welded joints, and the importance of providing suitable details to describe typical connections, unusual connections and necessary stiffening of component members. The importance of providing governing forces for analysis and design of connection details is also emphasized. In addition some illustrative examples will be used, and some simple design aids introduced to facilitate the checking and design of eccentric connections and connections with bolts in tension.

The presenters will highlight major changes in S16-09 that influence the design of structural steel connections. The "Connections for Steel Structures" notes, included in the course registration, references the Tenth Edition of the CISC Handbook of Steel Construction (2010), which contains CAN/CSA-S16-09 and CISC Commentary.

Halifax, NS	Nov. 2	Vancouver, BC	Nov. 17
Fredericton, NB	Nov. 3	Ottawa, ON	Nov. 30
Montreal, QC	Nov. 4	Toronto, ON	Dec. 1
Regina, SK	Nov. 15	Winnipeg, MB	Dec. 2
Edmonton, AB	Nov. 16		

Steel Handbook Highlights – New Course –
This course covers the design of steel members and elements using the recently published 10th Edition of the Handbook of Steel Construction. The intent 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.

Major changes and new provisions introduced in CSA Standard CAN/CSA-S16-09, "Design of Steel Structures" will be highlighted. However, overall building behaviour and seismic design are outside the scope of the Handbook of Steel Construction and this course. Seismic design is covered in a separate CISC short course - Seismic Design of Steel Framed Buildings, which is offered in major centres across Canada.

Webinar Format (4 x 2 hrs)

September 20, 22, 27, 29 - 2 pm EDT
November 9, 10 - 11 am & 2 pm EST
December 6, 7, 8, 9 - pm EST

Industrial Building Design
The course illustrates the limit states design of a single-storey industrial building. It refers extensively to the National Building Code of Canada 2005 (NBC 2005) and to CAN/CSA S16.1-05 "Limit States Design of Steel Structures" including the S16.1-05 Supplement, with emphasis on the applicability to typical Industrial buildings. In addition, there are references to the CISC Crane-Supporting Steel Structures: Design Guide, 2nd Edition and various AISC publications.

The example industrial building comprises common structural steel components used in roof and wall framing, such as roof trusses, crane runway beams, segmented columns, wall systems and standing seam roof systems. The building also serves to illustrate the design of a steel braced frame to resist wind and seismic loads, in accordance with NBC 2005 and S16-01. The course examines various design and construction topics, including; loads and load combinations, companion action approach, notional loads, vibration and fatigue, diaphragms, connections, foundations, coatings and corrosion considerations, low temperature toughness, rehabilitation, fire considerations and construction issues.

Toronto, ON	Sept. 21, 2010
Edmonton, AB	Sept. 22, 2010
Vancouver, BC	Sept. 23, 2010

Bolting and Welding For Design Engineers
This popular course is designed to provide an introduction to the basics of bolting and welding of steel structures with emphasis on practical and economical solutions. Although not a connection design course per se, participants will come away with a solid understanding of the materials, products, specifications, installation, field challenges and design methodologies for connecting structural steel components.

Thunder Bay, ON	Oct. 5	Calgary, AB	Oct. 19
Toronto, ON	Oct. 6	Kelowna, BC	Oct. 20
Saskatoon, SK	Oct. 7	Victoria, BC	Oct. 21

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 2005 National Building Code of Canada and the pertinent provisions of CSA Standard S16-01, including S16S1-05.

Toronto, ON	Oct. 26
Vancouver, BC	Nov. 30

Continuing education courses in development include:

- Design of connections in steel seismic force resisting systems
- Steel Bridges Design, Fabrication and Construction – Update to CSA S6-10 standard, plus a general refresh of the course material and a strengthening of fatigue and fracture topics

Please check the web site for updates: **www.cisc-icca.ca/courses**

NEW MEMBERS

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

DETAILER

KGS Group Steel Detailing Division
865 Waverley Street, 3rd Floor, Winnipeg, MB, R3T 5P4
Tel: 204 896 1209 | Fax: 204 896 0754
www.kgsgroup.com

SDE Structure D'Acier
500 Cote Richelieu, Trois-Rivieres, QC, G9A 2Z1
Tel: 819 376 9089 | Fax: 819 376 8302
www.sde-draft.com

EVENTS

Steel Day
September 24, 2010
Various locations across Canada
www.steelday.ca

The Pacific Structural Steel Conference 2010
October 19 – 22, 2010 Beijing, China
www.pssc2010.com

International Symposium on Tubular Structures
December 15 – 17, 2010 Hong Kong, China
www.hku.hk/civil/ISTS13

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

ATLANTIC

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

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

QUEBEC

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

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

Groupe Canam Inc. S, J
Boucherville, QC 450 641 4000

Groupe Canam Inc. S, J
Ville de St-Georges, QC 418 228 8031
www.canam-poutrelle.ws

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

Locweld Inc. S
Candiac, QC 450 659 9661
www.locweld.com

Métal Moro inc S
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www.metalperreault.com

Mometal Structures Inc. B, S
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www.mometal.com

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www.pmibuilding.com
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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 - ponts, une division de Groupe Canam Inc. S, P
Québec, QC 418 683 2561
www.structalponts.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

ONTARIO

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

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

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

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

Groupe Canam Inc. S, J
Mississauga, ON 905 671 3460
www.canam-steeljoist.ws

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

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Lorvin Steel Ltd. S
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

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www.marianimetal.com

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www.mbssteel.com

Mirage Steel Limited S, J
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www.miragesteel.com

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

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Orillia, ON 705 326 3619
www.norweld.com

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

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

Pittsburgh Steel Group S
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www.pittsburghsteel.com

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

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

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

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

Spencer Steel Limited S
Ilderton, ON 519 666 0676
www.spencersteel.com

Steel 2000 Inc. S
Chelmsford, ON 705 855 0803

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

Times Iron Works Ltd. S
Pickering, ON 905 831 5111

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

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

Victoria Steel Corporation S
Oldcastle, ON 519 737 6151

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

CENTRAL

Abesco Ltd. S
Winnipeg, MB 204 667 3981

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

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

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

Empire Iron Works Ltd. S
Winnipeg, MB 204 589 7371
www.empireiron.com

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

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

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

Supreme Group Inc. S, P
Saskatoon, SK 306 975 1177
www.supremesteel.com

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

ALBERTA

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Edmonton, AB 780 465 0381
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Capital Steel Inc. S
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Collins Industries Ltd. S
Edmonton, AB 780 440 1414
www.collins-industries-ltd.com

Empire Iron Works Ltd. S, P, J
Edmonton, AB 780 447 4650
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www.ledersteel.com

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www.moli.ca

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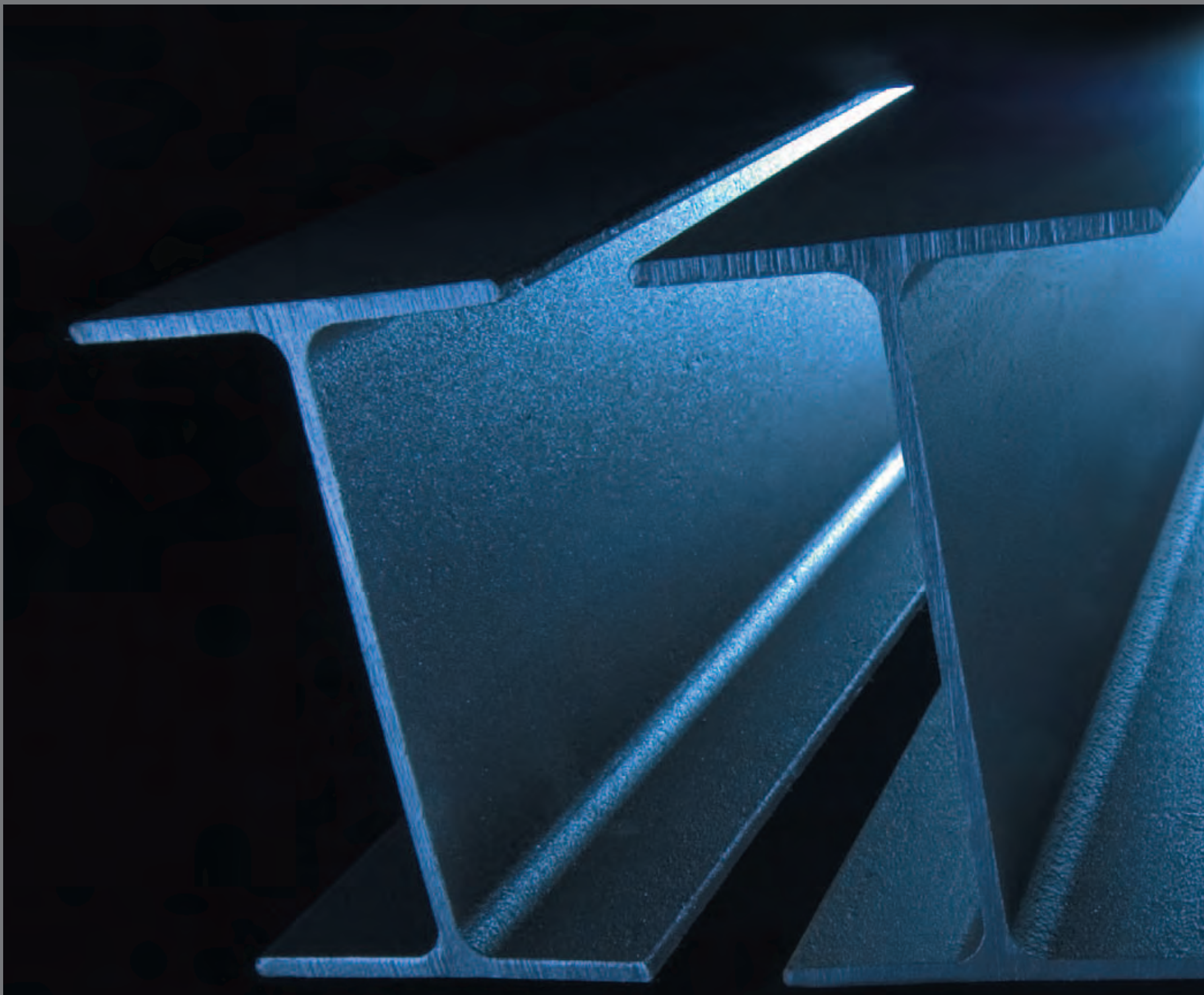

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Clint S. Low, P.Eng., Vancouver, BC	604 688 9861
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Ciro Martoni, ing., Montréal, QC	514 340 0046
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Philip A. McConnell, Edmonton, AB	780 450 8005
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Serge Parent, Oakville, ON	905 808 0344
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Alain Pomerleau, St-Jean-Sur-Richelieu QC	450 357 0955
Bertrand Proulx, ing., Shawinigan, QC	819 537 5771
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Dan S. Rapinda, P.Eng., Winnipeg MB	204 488 6674
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Serge Vézina, ing., Laval, QC	514 281 1010
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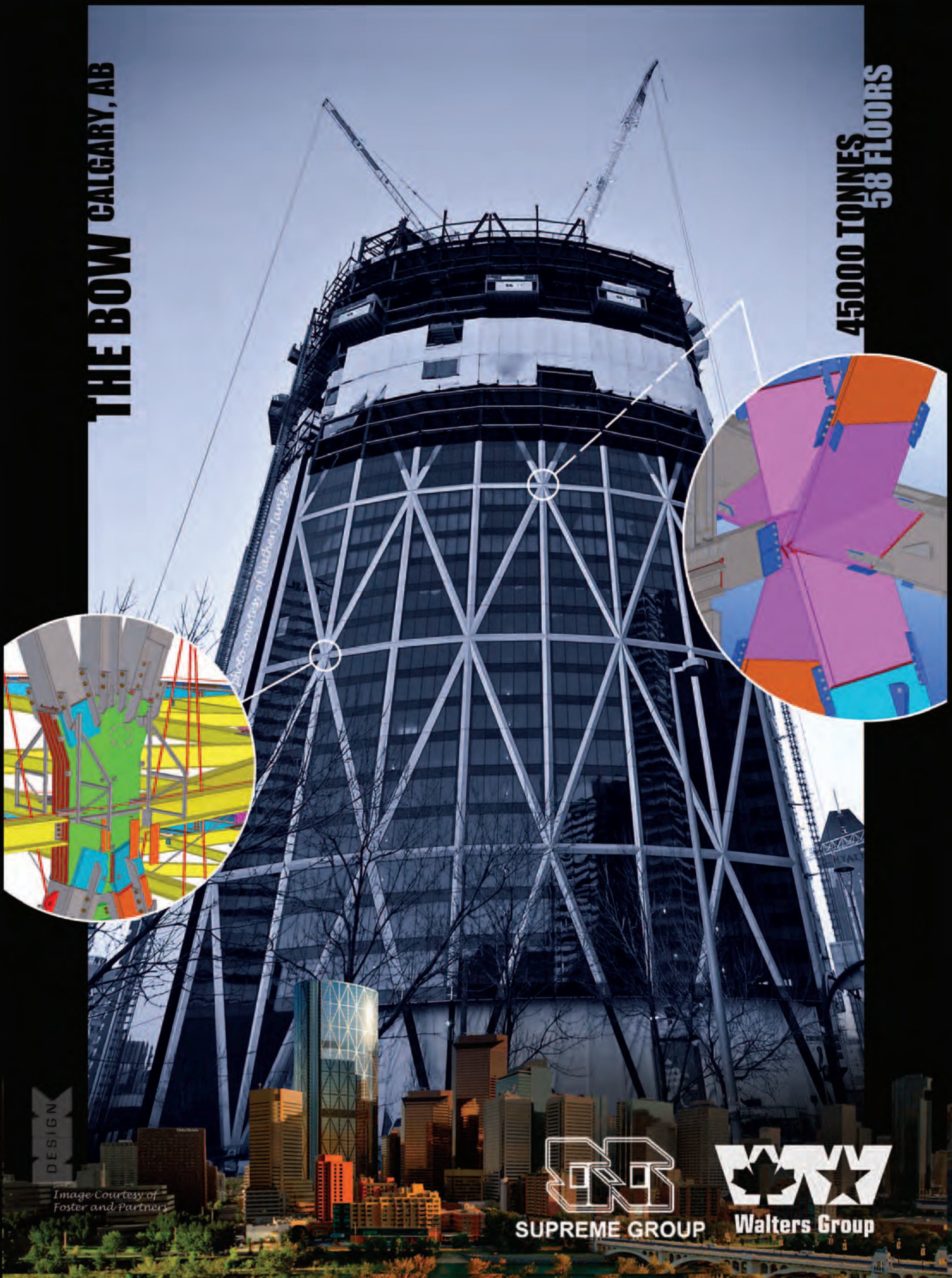
Dave R.M. Vrkljan, Calgary ,AB	403 251 2578
M. Declan Whelan, P.Eng., Hamilton, ON	905 523 1988
Chell K. Yee, Edmonton, AB	780 488 5636
Ken Zwicker, P.Eng., St. Albert, AB	780 458 6964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