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FROM THE EDITOR

In the modern trend of glass and steel, in structures like the crystals of the Royal Ontario Museum, rapid transit stations, new airports across Canada for example, structural steel is increasingly being exposed to view. In this issue, two architects discuss architecturally exposed steel.

This spring, plate walls are found sprouting up in Quebec, such as in the offices of ING. Read about its advantages for these projects, and again the steel industry is proud to highlight its Design Award Winners for 2004 from across Canada, in this issue.

While much of Canada is not subject to seismic risk, a significant portion of the population is, for which substantially more comprehensive provisions for seismic design have been proposed for the 2005 edition of the National Building Code. Steel structures not only attract substantially less seismic forces than those built of heavier materials, they provide a strong and ductile response. A new feature "Seismic Corner" in this issue will help those designing for seismic conditions.



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COVER PHOTO Exposed Steel – Ottawa Airport
 PHOTO TOP LEFT Courtesy of Duclos Fornier architectes
 ING building rendering
 PHOTO TOP RIGHT Courtesy of Lapointe Magne et
 Associés-Centrale Beauharnois

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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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Photo by: Adrien Voulez

Sylvie Boulanger, P.Eng. Ph.D.

Ask Dr. Sylvie is a column for Advantage Steel aimed at readers seeking technical information on steel structures. Questions are welcome on all aspects of design and construction of steel buildings and bridges. 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. Questions for Dr. Sylvie, or comments on previous questions, may be submitted by e-mail to sboulanger@cisc-icca.ca.

Can you explain why (according to my calculations) I need to use heavier beams and joists to satisfy the vibration criteria of S16-01, Appendix E, as compared to the results obtained from S16.1-94, Appendix G? – J.L.

The new criterion, as you know, is based on the 70-page, *AISC/CISC Steel Design Guide Series 11* by T.M. Murray, D.E. Allen & E.E. Ungar, entitled **Floor Vibrations Due to Human Activity**, available from our publications section (www.cisc-icca.ca) for \$25. To answer this question, I sought help from one of the authors! Dave Allen, well-known international expert and researcher at NRC's Institute for research in construction, responds:

I reviewed the calculations provided by J.L. and provide the following comments:

■ There is a substantial difference between the two criteria for joist floors on flexible girders. Based on considerable experience of unsatisfactory joist floors on flexible girders we had to change the old criterion, which was based on joist floors on stiff supports. The basis of the new criterion is contained in the paper by myself and Murray in the *AISC Engineering Journal*, December 1993, pp. 117-129*. Since 1993 I have investigated many of these floors, which were unsatisfactory to the users but satisfied the old criterion. An example is contained on page 57 (shown in Figure 7.2) of the *AISC/CISC Guide 11*. The cost of stiffening these floors is substantial.

■ The cost of satisfying the new criterion is not as severe as J.L.'s calculations indicate. Most of the problem floors, and especially the most serious ones, are primarily due to a concrete deck that is too thin. His calculations are correct except that he did not include the floor stiffening because the girder span (L_g) is less than the effective width of the joist panel (B_j) (see Figure 4.2 of the Guide, Step D). J.L.'s calculations and my calculations show that increasing the member sizes only (not the slab thickness or member depths) requires nearly twice as much steel. My last calculation, however, shows that increasing the slab thickness, as well as the joist and girder depth, results in no increase in joist steel and a small increase in girder steel (0.35 psf of floor area).

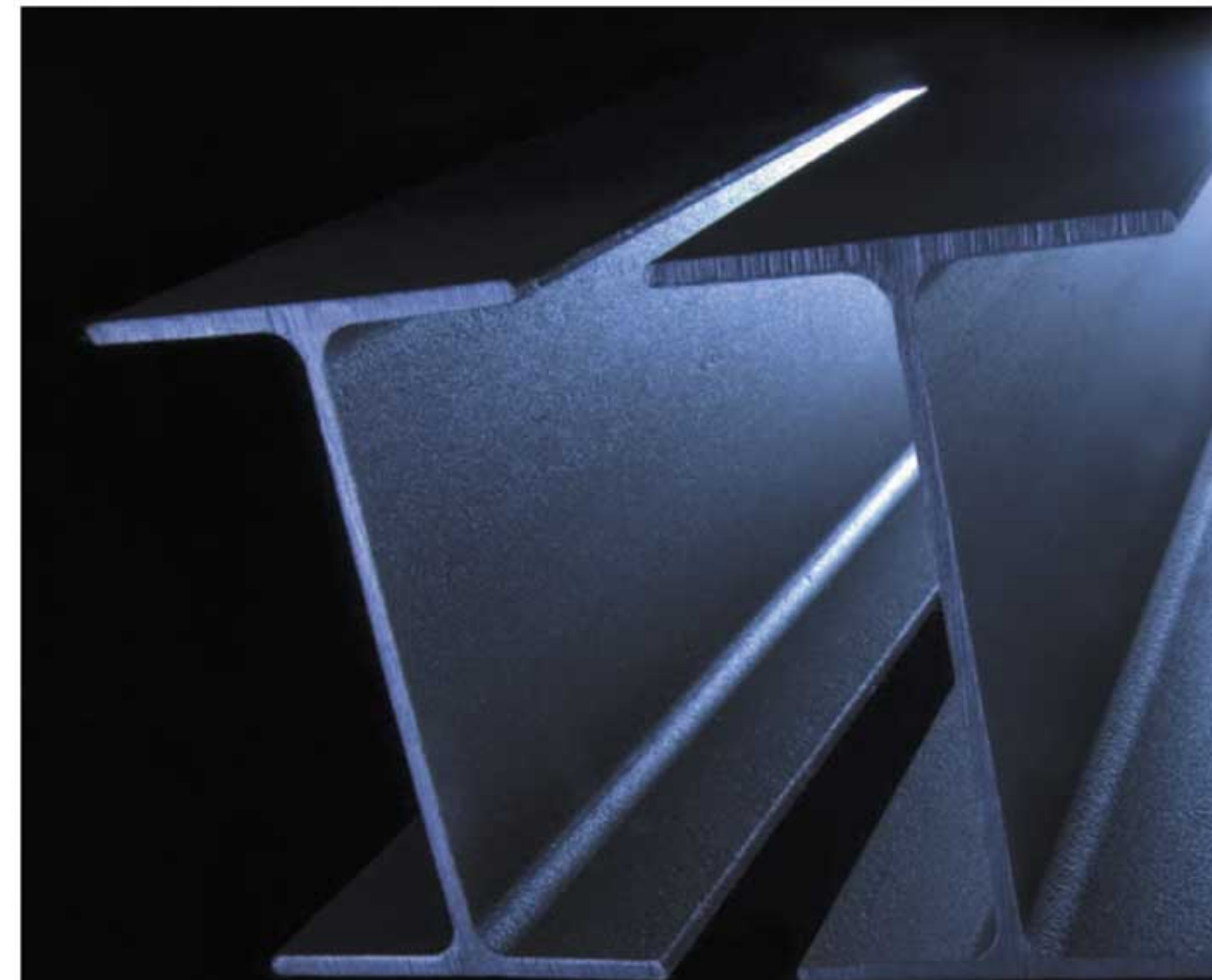
Thank you Dr. Allen. Hence, working on several parameters provides the best results. Bear in mind that the AISC/CISC document is a non-mandatory guide. It is a tool that helps engineers design a floor system and then discuss it with their clients. If the owner has dealt with similar buildings in the past that he found acceptable (or unacceptable) then this may be a good starting point. We also have an example that is included in our very popular **One Day Steel-Framed Office Building Design Course**. The course notes will be available for purchase after the Winter/Spring series of courses take place.

*This article, entitled *Design Criterion for Vibrations Due to Walking*, can be obtained from the AISC web site (www.aisc.org) in pdf format, by clicking on 'epubs' and then 'Engineering Journal', and entering the following keywords: Allen (author), 1993-Q4 (date).

Our firm is involved in a joint-venture effort for the design of a new series of LRT platforms. We think that a number of components in our steel superstructure lend themselves to steel castings. Can you provide information? – V.H.

How innovative to be considering steel castings in your platform design. I hope I can help. As you know, the characteristics of today's steel castings have nothing to do with its earlier cousin: cast iron. Steel castings are higher strength, weldable and more ductile. You generally see castings in conjunction with cable and glass structures, or in complex tubular joints for buildings or bridges. While common in Europe, there is a definite trend emerging in North America. At the CDP building in Montreal for example, steel castings were used for the first time on complex steel tube joints for an 8-storey high glass façade. The foundry was Castech.

I wrote a short article (*how's your French?*), with photos, of a talk that was presented at a North American Steel Construction Conference. www.quebec.cisc-icca.ca/content/messageboard/archives/000052.asp



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The talk is part of the proceedings that I received on a CD, but I have permission from the author and AISC to make it available. www.quebec.cisc-icca.ca/Library/pdf/castings_schober.pdf

The author, Hans Schober, is a partner at the renown German firm in Stuttgart: Schlaich, Bergermann und Partner (www.sbp.de). Hans Schober showed several impressive examples of steel castings in cable net walls and tubular bridge structures. Although most of the examples were "high-profile" projects, suggesting that perhaps steel castings are not cheap, there were always valid reasons that justified their use.

Hence, for castings to work, you need a reason! Do you have repetition (so the cost of making the mould is partly amortized)? (A must) Are there many elements coming to one point? Do you want to use castings in a high-stress zone? Do you have a foundry in your area that has the expertise? Would castings provide aesthetic advantages? If you answer yes to at least 3 of these questions, then maybe it deserves further investigation.

I heard of a rough 'rule of thumb' that if the connection started to cost four times as much as the material it is made of, then steel castings start to be interesting. You should note that the surface of the castings is not the same as the surface of a rolled steel shape or plate. Also, there are limits in thickness (6 mm is

suggested), and it is not possible to apply mechanical energy to modify or increase the properties of the moulded material. The material standards for castings are not the same as the standards used for rolled steel shapes and plates.

Since I answered this question, I met one of the engineers of the design team who said the project had gone through. Congratulations! However, he admitted it was not obvious in the beginning how to get involved, as this was the first time he had dealt with steel castings. As architects express steel more and more, I am confident that their use will increase, and innovations will continue.

I am presently calculating the resistance of an existing structure. Can I use a ϕ factor of 0.80 on the bolted connections? – S.C.-Q.

Certainly. The increased ϕ factor from 0.67 to 0.80 between CSA S16.1-94 and S16-01 is due to a second change that reduces the strength in lap shear joints as the joint length increases instead of a sudden decrease when the joint length exceeded 1300 mm. Thus, there is no explicit reason discouraging the use of 0.80 when evaluating existing buildings, as long as the joint length is also taken into account. The joint length requirement is not applicable to standard beam shear connections.

SEISMIC CORNER



British Columbia Institute of Technology

Recent event in Asia and on March 6, 2005 – 17km from Rivière-du-Loop, Quebec a magnitude 5.4 earthquake occurred – remind us all that while rare, earthquakes do and will occur. For anyone interested, a map of Canadian seismic events and magnitudes is available at www.pgc.nrcan.gc.ca/seismo/eqhaz/canq.htm.

Actually one of the world's largest earthquakes occurred on the west coast of Canada at 9 p.m. on January 26, 1700 (Source: National Resources Canada). In Quebec, historical earthquakes have exceeded magnitude 7.0. However, much of the remaining part of Canada is at low seismic risk.

In Canada, the National Research Council's Canadian Committee on Earthquake Engineering (CANCEE) is a group of seismologists and structural engineers responsible for developing the requirements for buildings to resist these rare events. Those requirements are found in two sources available to designers (a) Part 4 of the National Building Code of Canada (NBCC) and (b) the structural commentaries to the NBCC.

The NBCC provides information for lateral-load-resisting systems of varying levels of ductility, and each of the CSA material design standards has commensurate clauses detailing the specific requirements for these various lateral-load systems.

Historically, structural steel systems have performed better than any other framing material; however, attention to detail and structural layout are very important to success.

CSA Standard S16-01 contains a number of different lateral-load-resisting systems with varying levels of ductility to provide a range of satisfactory solutions for buildings in Canadian seismic risk zones. Such systems as plate walls shown here in a new building in Quebec provide proven stiffness and ductility.

In future columns, other aspects of seismic design will be discussed.

In this column, we will also keep you informed of the software developers who have announced software features that incorporate CSA S16-01 Chapter 27 clauses.

In this issue, we have been informed that Civil Design has revised its popular Visual Design software to incorporate the design of eccentrically braced frames. Denis Lefebvre, who founded Civil Design, says that the CBF module will be available soon. For further details, see www.civildesign.com.

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Courtesy of Quirion Métal Inc. ING building during construction phase



Courtesy of Dessau-Soprin Shear wall inside the IRCM building



Courtesy of NFOE Architects Completed IRCM building

By JK Malmgren

NEW AND REHAB PROJECTS FEATURE PLATE WALL SOLUTION

The use of a steel plate shear wall (or simply a plate wall) using a thin unstiffened plate has been pioneered in Canada both in terms of research and in actual use. The first, a seven-storey plate wall system was used for the extension of the offices of CANAM in Saint-Georges, Quebec, in the early nineties. A significant use of a plate wall solution in the United States is the new Seattle Court House. Given the clear benefits to this method of dealing with seismic load, it has been used for a high-rise residential building in Mexico and luxury housing in California. The expanded clauses in the steel standard addressing plate walls have assisted designers with adopting this type of construction.

The advantages of a plate wall over both a concrete equivalent and a more traditional brace system are often a matter of time and space. Plate walls take up far less space than concrete, and far less steel than a brace system. In terms of time, steel's edge in onsite efficiency is an advantage, one that can be heightened by taking much of the assembly off site, as has been shown in a couple of recent Quebec projects.

Both the five-storey ING building in St. Hyacinthe, and the two-storey addition to one wing of the Institut de Recherches Cliniques de Montreal (IRCM), utilized a plate wall as a means of dealing with seismic load to meet R=2 values.

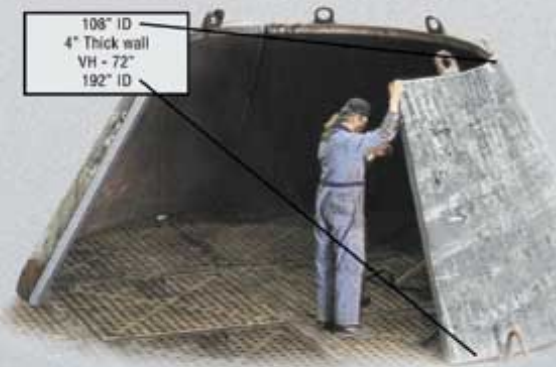
Although designers and engineers arrived at the method from slightly different directions, the solutions developed in working with fabricators took remarkably similar paths.

The ING project, which was awarded through a design contest, is non-symmetric. It includes a four-storey curved glass curtain wall that faces south onto the river, and segments into different working environments that help fulfill ING Canada's goal of an expansion that would be modern, beautiful and employee friendly. Duclos Fournier architectes, which won the contest and was awarded the design contract, discovered fairly quickly that its original concepts created some difficult construction challenges.

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"The initial project was in concrete," explains Duclos Fournier principal and project architect Jean Carol Fournier. "Given the winter conditions and the recommendations from the engineer, we quickly iterated toward a steel solution, to our greatest satisfaction."

The efficiencies of steel construction were multiplied by implementing a plate wall system.

"We were supposed to initiate a concrete shear wall," says Jean-Benoit Ducharme, P. Eng, project engineer with Groupe Teknika. "But we wanted to have one type of construction material and one contractor."

Ducharme benefited from the experience of Groupe Teknika's director for structural design in Montreal, Louis Crepeau, who has extensive experience in plate wall design. Understanding the parameters inherent in the system, he saw the ING project as a perfect opportunity to utilize this method.

"It's a pretty big building," says Crepeau. "We needed the rigidity – concrete is rigid, but it would have been much, much bigger."

The design team looked first at a more traditional bracing system, but quickly realized that any space saved by moving from concrete to steel would be lost that way.

"There are shear walls in each direction to have enough capacity for the torsion," says Crepeau. "If it was cross-bracing, we would have needed twice as much material to have the strength – we were amazed with the strength the plate gave to the building."

The solution designed for ING was a two-sided plate wall cage that sits in the centre of the rectangular building, stretching up 25 m. The plate wall not only used much less steel, making it more cost effective and also much more quickly constructed, it became a simply better design solution.

"It's very rigid with plates versus bracing," says Jean-Benoit Ducharme. "We wanted to limit the sway, it's the only thing that will take the horizontal force."

For the IRCM project, which included adding floors to two joined existing buildings, the original construction method drove the final design.

"The taller building was already in concrete, so the extra floors were done in concrete," says Luc Dumais of Dessau-Soprin, structural engineer for the project. "The second building was a one-level steel structure, we added two stories using steel."



Courtesy of Quirion Métal Inc. A close up of the plate walls in the ING building

The complete project would be a three-storey steel structure plus a mechanical penthouse, and the existing floor needed to be reinforced to meet seismic requirements with the addition of the new stories above. The plate wall system provided a perfect solution.

"We thought it was an efficient way to take the lateral loads," says Dumais. "And also a convenient way to bind the existing structure to the new one."

And Dumais was impressed with the size and efficiency of plate wall, but also the way in which it dealt with the load itself.

"The lateral load generates a moment and a shear," explains Dumais. "When you use a brace system all of the load is taken by the

joint, but when you use a plate system, the shear is taken by the plate."

Two plate walls were utilized in the IRCM project, each 3 m wide, one 4.8 m high, the other 3.5 m high.

"One plate wall is two stories high, it goes from the existing roof to the new roof," says Dumais. "The other goes right up from the basement."

The architectural treatment of the new additions offers a contemporary image reflecting the innovative nature of the research being carried out within the Institute. Designed by Mike Sullivan, NFOE et associés architectes, the curtain wall façades of the vertical addition to Bloc Basset are intended as a backdrop to the dynamic composition of the additions to Bloc des Pins. The diagonal brick wall of Bloc des Pins was introduced to respect the existing semi-circular tower of Bloc Basset and to increase the setback from the adjoining neighbouring residential area. This angled wall also provides a view from a main corridor towards Mount Royal and towards the historical buildings across the street, giving a sense of orientation. The requirement for good environmental control in the animal facility necessitated a large expanse of windowless exterior on the principal façade. In some ways, this made the use of plate wall easier.

"It's not possible to put in openings if you do you interrupt the diagonal tension," says Dumais. "You have to deal with the architect to place it in such a way that you don't create an obstruction."

Just as designing plate walls was a new and enlightening process for the consultants and architects, the fabrication of the elements led to some innovation of its own. The plate wall is essentially two columns with a plate in between – a plate that needs to be thick enough to weld, but thin enough to control the load.

"The minimum thickness is 5 mm. If you go below that, it's too hard to weld," says Teknika's Louis Crepeau, pointing to the design limitations.



Courtesy of Duclos Fournier architectes ING building rendering

From a fabrication point of view, the thin plate was somewhat difficult to weld, but also provided other challenges.

Fabrication for the ING project, which included two 25 m high plate walls, was undertaken by Quirion Metal, while Les Constructions Beauce-Atlas undertook the work for the IRCM addition. Each derived a solution best suited to the individual project, but each took the path of doing as much of the fabrication off-site as possible.

For the IRCM project, the thin 6.5 mm plate created inherent local deformation, but Beauce-Atlas was able to remedy these using heat to bring the plates within a reasonable out-of-straightness tolerance.

"Our experience with the fabrication of welded wide-flange girders helped us deal with the welding of the plate," says Beauce-Atlas' Martin Savoie, project manager.

PLATE WALL RESOURCES

- CSA S16-01 Clause 20; Clause 27.8.2 for R=2.0 and Clause 27.8.3 for R=5.0

- CISC Commentary, Handbook 8th edition, pp. 289-294

- Preliminary Design, in a nutshell (extracted from Commentary)

- For preliminary design, the overall behaviour of a plate wall can be approximated in a plane frame analysis as a vertical truss by representing each web panel by a single diagonal tension brace

- A strip model predicts the development of tension field action in plate walls subjected to lateral loads

Here, the decision was made to deliver each of the two plate walls in a single very large piece, making shipping itself complex, but actual installation extremely fast and simple.

"There are far fewer connections to be made on site, which greatly speeds up the erection process," says Savoie. "Next time, we will be even more efficient."

For the larger plate walls of the ING project, Quirion Métal took a similar but slightly different approach. Again, the decision was made to take as much fabrication as possible into the plant. Their recommendation was to deliver the shear wall in two vertical segments, and perform a weld from bottom to top on site. That meant transporting two 6-storey segments (80' long pieces) for each plate wall.

"We decided to "zip" four of the five plate walls on site, the fifth one could be handled in one piece," says Stéphane Brisson, of

Quirion Métal. "This saved a lot of erection time. Then, only one worker was mobilized to do the six-storey vertical weld! The splices on the beam were bolted."

Quirion faced a second challenge. In St. Hyacinthe, the poor soil condition means that structures often have foundations built on pilings. Tolerances on the anchor rods were critical, and a wooden template was made in the plant to avoid any mistakes on site.

The projects represented a first foray into plate wall construction for everyone involved – designers, consultants and fabricators. But each saw a tremendous advantage, first to an all-steel solution, but also to a compact, efficient system that could be largely fabricated off-site.

"Knowing that we are responsible for the core facilitated the coordination for the foundation work and the floor connections," says Brisson. "It was a good experience. We're looking forward to having the opportunity to do another plate wall system."

And, while there is recognition that the system works best with certain types of projects, the engineers also look ahead to utilizing plate walls again. One engineer has recently designed plate walls to rehabilitate a concrete residential building.

"It's a very stiff, compact system," concludes Dessau-Soprin's Luc Dumais. "We followed CISC's Commentary as a guideline, we thought it was very straightforward to design."

- For plate walls of sensible proportions, the angle of inclination for the inclined truss members is to lie between 38° and 45°

- The forces and moments in a plate wall may be determined by extending the strip model over all stories using a plane frame structural analysis program. Ten strips per panel have been found to be sufficient.

- 'Steel Plate Shear Wall Evolution in North America', by Peter Timler, *Advantage Steel* no 14, Winter 2000. – www.cisc-icca.ca

- 'Steel plate shear walls— an overview', *AISC Engineering Journal*, 38(1), Kulak, G.L., Kennedy, D.J.L., Driver, R.G., and Medhekar, M. (2001, First quarter) – www.aisc.org

- 'STEEL PLATE SHEAR WALLS Now Performing on the Main Stage - A new player in a leading role', *Modern Steel Construction*; September 2001 issue, Robert G. Driver, P.Eng. and Gilbert Y. Grondin, P.Eng. – www.aisc.org

ARCHITECTURALLY EXPOSED STRUCTURAL STEEL:

HOW IS IT DEFINED?

By Terri Meyer Boake BES B.Arch M.Arch LEED AP



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Ontario College of Art and Design

Vancouver Airport

The modern application of steel in architecture has given way to a bold new set of manifestations. The exposed use of steel in design and construction has become a popular trend and method of architectural expression. Both standard steel shapes and steel tubes or HSS sections are being employed to create the architectural character of a building. This style is defined as “Architecturally Exposed Structural Steel” (AESS).

Architecturally exposed steel construction has its history rooted in some of the famous cast and wrought iron structures of the early to mid-1800s. These structurally rationalist buildings used the qualities and detailing of iron components and fastenings to define the architecture of the space. Nothing was concealed. The craftsmanship was often exquisite.

Issues with fire protective design and related fatalities at the end of the 1800s, resulted in the majority of steel structures being covered with layers of gypsum, plaster and concrete. Steel connection detailing became extremely pragmatic and functional. Not until the high-tech movement of the early 1970s, followed by increased incidence of atrium spaces, sprinkler systems, new fire codes, and finally, the invention of intumescent paint coatings, did we see a real resurgence of the use of architecturally exposed structural steel in buildings. In Toronto, these early efforts may be characterized by the construction of the Eaton Center and Ontario Place.

Airport architecture has succeeded in pushing the use of exposed steel to incredible heights. Whereas the use of a fully exposed steel structure may not be allowed by the building and fire code for certain occupancies, airline terminal buildings do permit such exposure, and this, combined with requirements for extremely large column free spaces, have pushed the exploitation of the structural characteristics of steel – in particular, steel tube and truss assemblies. Expansions to Terminal One at Pearson International Airport in Toronto, to the Vancouver Domestic and International Terminals, and to numerous other terminals across Canada and the U.S., are using AESS as their material of choice.

Much of the architectural enjoyment, as well as challenge in designing with AESS is in the creation of the key details and

connections that give the structure its distinctive character. After the primary choice of member type and system (shape vs. tube), the challenge lies in determining the method of connection – welding vs. bolting, and ultimately the design of the joint itself. Whereas designers tend not to be involved in connection issues for concealed structural systems, exposed systems become the architectural trademark of the building, hence requiring much involvement. Unfortunately, not all designers are adequately informed to choosing appropriate connection methods or to the cost implications of their choices. Detailing can be fun, if approached from an educated perspective!

The basic understanding of steel construction lies in its roots. Steel artistry is reliant on not only the appropriate choice of members (shapes versus tubes), but also heavily on the method of attachment. When creating joints between members, AESS design requires detailing according to industrial design standards. The structural requirements of shear and moment resistance must be accommodated, along with tighter dimensional tolerances, and other considerations such as balance, form, symmetry and economy. If the connections require an excessive degree of unique fabrication details, the designer can price the project out of existence; however, the method of preparation and finishing for the connections can radically increase costs. Specialized welds and unnecessary ground and filed finishes increase fabrication and erection expenses.

To this point in time, courses in both architecture and engineering schools do not tend to prepare students beyond the preparation of fairly standard connection details. Efforts are underway through the Steel Structures Education Foundation (SSEF) to create educational materials that address this deficiency.

Construction sequencing for architecturally exposed steel members can place limitations on detailing and increase the challenge of erection. The 90-foot long steel columns that support the upper structure of the addition to the Ontario College of Art and Design were pre-finished at the fabrication shop with a coloured fire resistant intumescent coating. Street access was extremely restrictive during the erection, and extra care had to be taken to preserve the integrity of the intumescent coating during handling and erection. A custom set of supports was constructed to hold the members in place until such time as proper lateral bracing could be provided. The integrity of the finish was also touched up intermittently throughout the construction process due to unavoidable nicks and scratches, the result of routine construction processes.

Intumescent coatings, although allowing exposed steel use in an increased number of occupancies, are not deemed by architects to be the best solution as they can result in a lumpy finish that can obscure some connection details. Fire protection methods for the exposed steel structure need to be determined early on as they should influence the type and design of connection detailing.

Some specifications for AESS place a higher level of workmanship requirements, above and beyond the regular structural and safety aspects of steel construction, to address the additional aesthetic and design considerations. Not only must more care be taken during the shop and field fabrication of the AESS product, but also other operations are necessary to raise the aesthetic and tectonic level of the steel for purely visual and tactile goals. It might be required to touch and feel the steel to ensure a smooth and defect free product, if situated at the public level.

If bolted connections are used, this may not be a difficult requirement as their tectonic characteristics are perceived to be somewhat busier, and the structural steel or tube itself is unlikely to require more than proper paint finishing. Welded connections can be at an extra expense due to the additional grinding operations. Specialty elements that require steel to be cast into unusual shapes, or bent into complex curves, also places additional requirements on the fabrication and installation that will increase the cost of the steel.

Such information needs to be conveyed to architects and engineers so that they understand the impact of line items in specifications. To illustrate the final expected result, a sample product board can be provided for each project along with a cost breakout to assist in differentiating the project costs related to high finish requirements in the exposed steel. Designers are then in a better position to both understand the product as well as the associated costs.

The examination of various AESS projects begs the question – *must all AESS buildings be designed to the same standard of workmanship?* It would seem that much unnecessary work is being carried out to make a product that is not always required to exhibit the sculptural qualities of buildings such as BCE Place by Santiago Calatrava.

Must steel that is situated 6 to 8 meters away from view be finished to the same standard as that within touching range? What happens when designers choose to use recycled steel elements (versus recycled steel % content) for reason of sustainable design as in the Chapiteau des Arts and Angus Technopole in Montreal? In both cases the designers are proudly displaying the reused state of the steel and have no intention of refinishing it to a sculptural standard. Yet it is technically architecturally exposed structural steel.

Is one answer possible or should there be a range of possibilities? Please stay tuned!

Terri Meyer-Boake is a Professor of Architecture at the University of Waterloo. She teaches in the area of building construction, environmental design and media. She has been the webmaster for the CISC website for the past two and a half years and is responsible for much of the documentation in the Project Gallery.

11th INTERNATIONAL SYMPOSIUM and IIW INTERNATIONAL CONFERENCE on TUBULAR STRUCTURES

August 31 to September 2, 2006 in Québec City, Canada

TOPICS

- ❑ Architecture, Applications and Case Studies
- ❑ Static and Fatigue Behaviour of Connections
- ❑ Concrete Filled Hollow Sections and Composite Tubular Members
- ❑ Offshore Structures
- ❑ Earthquake Resistance
- ❑ Specification and Standard Developments
- ❑ Expert Systems and Knowledge-Based Systems
- ❑ Material Properties and Structural Reliability
- ❑ Sustainability of Tubular Structures
- ❑ Fire Resistance

EXHIBITION
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For further information, including the Call for Papers, please visit the website at:
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Charlevoix - An Enchanting Region

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WHAT'S COOL, WHAT'S HOT, WHAT'S NEW

NEW BOLT GUIDE

Dr. Geoff L. Kulak has written a guide for bolted joints specifically for Canadian engineers. CISC is pleased to be publishing 'High-Strength Bolting for Canadian Engineers', which should be a handy reference for all those involved in steel design employing bolted connections as it provides guidance for many practical and common conditions. For more information visit www.cisc-icca.ca

CSA S16S1-05

In order to properly interface with the new loads, load combinations and seismic requirements of the National Building Code of Canada 2005 edition (set for release later this year), CSA Standard S16 requires a supplement, called S16S1-05, now available from CSA (www.shopcsa.ca). While the bulk of the changes only apply once the NBCC 2005 is adopted, there are a few changes to existing clauses to update reference standards, to improve a couple of clauses, and to introduce a new welding clause for flare-bevel groove welds for open-web steel joists.

The bulk of the changes relating to NBCC 2005 are concentrated in Clauses 6, 7 and 27.

SSEF NEWS ARCHITECTURAL STUDENT DESIGN COMPETITION

Now in its fourth year, this competition for which the students must design a small steel structure has attracted entries from 123 student groups representing 8 schools of architecture from across Canada. Final entries will be judged in May. Good luck and watch for the winners here later.

CISC STEEL FABRICATION QUALITY SYSTEMS GUIDELINE

To date, the following CISC Fabricators have implemented the Quality Systems Guideline and have also been audited and registered by Quasar:

DALHOUSIE UNIVERSITY ANNOUNCES FIRST SSEF SCHOLARSHIP WINNER

A series of scholarships has been established by SSEF to promote excellence in Steel Design in Architecture. Dalhousie has announced the first winner, Jeffery Skinner, for his thesis on the Shannon Park Dismantling and Redistribution Centre. This project is focused on reuse and sustainable aspects while using structural steel.



ATLANTIC REGION SCHOLARSHIP WINNER (from left to right):
John Wilson, President, International Association of Bridge, Structural, Ornamental, and Reinforcing Iron Workers, Local 752; Roy Aylward, Business Manager International Association of Bridge, Structural, Ornamental, and Reinforcing Iron Workers, Local 852; Yi Liu, Assistant Professor, Department of Civil Engineering, Faculty of Engineering, Dalhousie University; Paul Burke, Scholarship Recipient, Fifth year civil engineering student at Dalhousie University; Alan Lock, Atlantic Region Marketing Director, Canadian Institute of Steel Construction

LUNCH AND LEARN

A series of Lunch and Learn seminars is making a hit with Architectural and Engineering Consultants offices in Atlantic Canada.

Al Lock, Atlantic Regional Marketing Director, has visited over 100 architects and engineers in Nova Scotia, New Brunswick and Prince Edward Island bringing not just lunch, but also what's new in the steel industry combined with a chance to ask industry

representatives detailed questions on areas of interest to each individual firm.

Similar meetings are being conducted in CISC's other regions by their respective Directors. In the Ontario Region, these seminars have been quite successful over the years and in January this year, Suja John, Ontario Regional Director had a chance to organize a luncheon seminar for over 65 engineers at Yolles.

Contact a CISC Regional Director in your area to arrange a Lunch and Learn seminar for your firm today. Contact information is available in the front of this magazine.

UPCOMING EVENTS

CISC's 2005 Annual Convention and 75th Annual General Meeting - June 15 - 19, 2005.

Le Manoir Richelieu in Charlevoix, Québec

7th International Conference on Short & Medium Span Bridges - August 23 - 25, 2006

Le Centre Sheraton Montréal Hotel, Montréal, Québec

The first call for papers has been released and the scheduled deadline to receive abstract submissions is June 30, 2005. So if you're interested in contributing to one of the technical sessions, for more information visit www.bridgeconference2006.com

11th International Symposium and IIW Conference on Tubular Structures - August 31 - September 2, 2006

Québec City, Québec

The first call for papers has been released with a deadline for submission scheduled as July 4, 2005. For more information visit www.ists11.org.

- Benson Steel Limited, Bolton, Ontario
- Empire Iron Works Ltd., Delta, BC
- Eskimo Steel Limited, Sherwood Park, Alberta
- Industrial Welding (1990) Co. Ltd., Saskatoon, Saskatchewan
- M&G Steel Ltd., Mississauga, Ontario

- Precision Steel & Manufacturing Ltd., Edmonton, Alberta
- Spec-Sec Incorporated, Rexdale, Ontario
- Supermetal Structures Inc., Sherbrooke, Québec
- Supreme Steel Ltd., Edmonton, Alberta
- Weldfab Limited, Saskatoon, Saskatchewan

STEEL MOVES TO CENTRE STAGE: AS IT IS REDISCOVERED IN THE ARCHITECTURE OF BUILDINGS

In Quebec, it has become fashionable once again to highlight the structural framework of buildings – and steel is front and centre in the trend.

“Right now, it’s trendy to show steel in all its many facets,” says Sylvie Boulanger, Executive Director for the Quebec Region of the Canadian Institute of Steel Construction, when asked about the growing use of steel for architectural purposes in office buildings.

Architects are uncovering and revealing steel by shaping it into more artistic designs which gives already steel-framed buildings greater individuality. Steel is also being used more and more on the inside of buildings, in seemingly unexpected and nontraditional ways.

“Still,” as Robert Magne, partner at the architectural and city planning firm Lapointe Magne points out, “this isn’t a new trend, it is a throwback to the modernist era of the 1960s.”

“It’s a matter of rediscovering, not reinventing,” he says. “Architects have always been able to use steel and concrete in technically expressive ways. We are looking for honesty and transparency in expression – we want it to be authentic – hence our interest in highlighting and showcasing the framework.”

Of course, the framework and cladding of a building are closely linked, and this is a guiding factor in the move toward highlighting the steel framework. New materials and technologies also play into the trend.

For example, you’ll see more glass in recent large-scale projects such as the expansion of the Palais des congrès de Montréal (Montreal convention centre), and the new offices of the Caisse de dépôt et placement, both in the city’s new international quarter. This allows the bones of the building to show through. Because of the glass, the steel frame and finely worked metal are highlighted.

“This new trend requires more rigor and cooperation between architects and engineers,” says Magne. “The engineer has to understand the challenge. A great deal of sensitivity and care

must be used in the execution, because when the structure is laid bare, it needs more regularity to be pleasing to the eye. Exposed steel demands refinement. Obviously, more control is necessary.”

Magne also points out that exposing the steel framework is in keeping with a new environmentalist trend – one that favours clear, clean, simple lines.

He doesn’t hide the fact that architects have to work with limited budgets in designing new buildings – which really motivates them to seek “simpler ways,” such as leaving steel bare.

Magne played the “simplicity” card to the hilt when he drafted the design of the École nationale de cirque (National circus school) in the Montreal area of Villeray-Saint-Michel-Parc Extension. Built in 2003, the École is quite ordinary in shape – i.e. a large rectangular cube.

“It was still quite a balancing act to build,” says Magne, “because of the coexistence of two structures – one in steel, the other in concrete. Steel was used lavishly in certain parts of the complex, especially the gyms, which are stacked.

In parts of the complex that had to be fire-resistant,” Magne explains, “some of the columns and beams are covered in intumescent paint, which makes it possible to leave the framework exposed.”

“Since the steel columns are relatively narrow, they don’t intrude too much on the open space of the gym. But the beams had to be very wide to extend over 20-metres. This could have been a handicap, but by exposing the beams, it was possible to place the mechanical systems there, and to let stage technicians pass through by means of a system of stretched steel netting.”

Magne weighed several options, but says the solution chosen was cheaper and faster to build than would have been the case with concrete. Also, on the south wall of the building, which is slanted and made entirely of glass, the architect had a light filtering system installed that is composed of steel parts.

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2004 CISC STEEL DESIGN AWARDS



Courtesy of Lapointe Magne et Associés
Centrale Beauharnois

INDUSTRIAL SECTOR

Even in the industrial sector, where buildings are generally not known for their design appeal and where the framework is rarely exposed, there are a few exceptions to the rule. Magne mentions the restoration and modernization of the Beauharnois hydroelectric facility. Even though the original building that was restored is still mainly in stone, the new East building features a large glass wall that highlights “a spectacular steel structure” and gigantic electrical wires. The steel structure houses the high-voltage cables running between the turbines and the new distribution equipment. The spectacular aspect comes from the fact that the building is 10-storeys high.

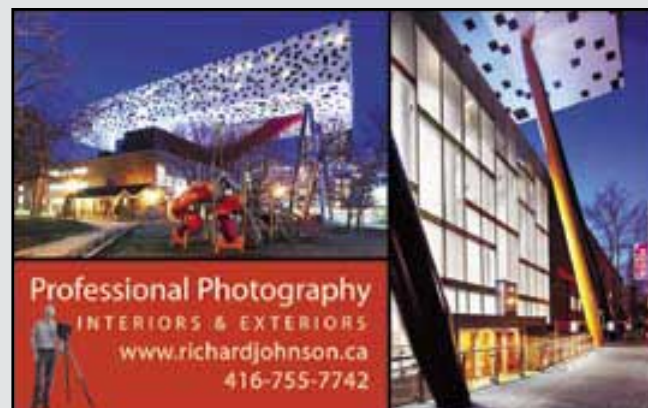
“Because of the striking contrast between the 1930s-era industrial building and the new structure, you have no trouble distinguishing between the various eras that are juxtaposed in this government-owned hydroelectric plant,” says Magne, who has been working as an architect since 1976.

“Even though steel is making a huge comeback in architecture we’re still a long way from what you’ll see in Europe,” says Magne. “Our architectural culture – and the finances allocated to it – are light years away from what you’ll find on the other side of the Atlantic.”

THIS ARTICLE ORIGINALLY APPEARED IN THE CAHIER SPÉCIAL SUR LE BÂTIMENT IN CONSTRUCTO (NOVEMBER 2004). IT IS REPRINTED WITH PERMISSION OF THE PUBLISHER AND AUTHOR.



Courtesy of Lapointe Magne et Associés École nationale de cirque



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Amgen Helix Bridge, Seattle
Seattle Weekly

Dongli Lake Pavilion,
China Ian Boyle, Fast & Epp

Millennium Park
Chicago Dowco

BRITISH COLUMBIA REGION AWARDS

KRENTZ AWARD WINNER –

AMGEN HELIX BRIDGE, SEATTLE

Owner: Amgen Inc.

Architect: Johnson Architecture & Planning

Structural Engineer: KPFF Consulting Engineers

General Contractor: Skanska

Steel Fabricator, Detailer and Erector: AMEC Dynamic Structures Ltd.

Modeling the shape of a helical DNA model, this phenomenal looking pedestrian bridge spans 400 feet over several working railway lines and was erected causing minimal interruption to the operations below. The successful completion was achieved through AMEC’s carefully planned welding sequences to avoid distortion problems, and accurate fabrication of the bridge’s components, most especially the deck and arches in their shop.

ARCHITECTURAL CATEGORY WINNER –

NATIONAL WORKS YARD, VANCOUVER

Owner: City of Vancouver

Architect: Omicron Consulting Group

Structural Engineer: Omicron Consulting Group

General Contractor: Omicron Consulting Group

Steel Fabricator, Detailer and Erector: Solid Rock Steel Fabricating Company Ltd.

This project not only demonstrates both the structural and architectural abilities of steel, it has taken a lead role in addressing environmental concerns for project management and sustainable design. The two main buildings in the National Works Yard (Administrative Centre and Parking Operations) were the first in Canada to receive LEED™ Gold Certification from the Canadian Green Building Council.

ENGINEERING CATEGORY WINNER –

MILLENNIUM PARK CHICAGO, CHICAGO

Owner: City of Chicago

Architect: Frank Gehry & Associates

Structural Engineer: Skidmore, Owings & Merrill LLP

General Contractor: Walsh Construction

Steel Detailer: Dowco Consultants Ltd.

Steel Erector: Danny’s Construction

Designed by world-renowned architect, Frank Gehry, Millennium Park has not only created a new green spot in downtown Chicago, but it also provides an outdoor venue for entertainment features such as art, music performances, ice skating, dining and more. The most visual component to this project is the music pavilion that was clad in stainless steel panels on the exterior. The ‘Gehry Ribbons’ also add an extraordinary visual component, composed of steel and bursting outwards up to 40 feet high.

ENGINEERING CATEGORY HONOURABLE MENTION –

DONGLI LAKE PAVILION, CHINA

Owner: Tianjin China

Architect: Busby + Associates Architects

Structural Engineer: Fast + Epp Structural Engineers

Steel Fabricator, Detailer and Erector: George Third & Son



Crowfoot Library
Kim Connell

Raw Ore Material Sizer
SNC Lavalin B.C.

ALBERTA REGION AWARDS

ARCHITECTURAL CATEGORY WINNER –

CROWFOOT LIBRARY, CALGARY

Owner: Calgary Public Library

Architect & Structural Engineer: Cohos Evamy Partnership

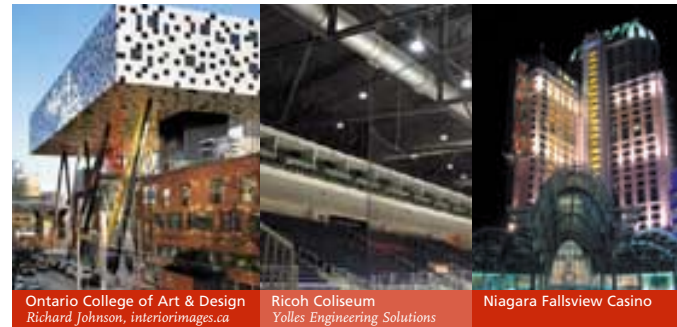
General Contractor: CANA Management Ltd.

Steel Detailer, Fabricator & Erector: Triangle Steel Ltd.

The Crowfoot Library is the first occupied LEED™ Certified (Silver) structure in Calgary. The judges concluded that this structure represents an environmentally conscientious facility, highlighted through features such as the galvanized steel exterior sunshades that reduce traditional heating costs. This structure was also designed so efficiently through the use of steel, that the development team was able to construct a larger building than originally planned, while still delivering it under budget.

**STRUCTURAL CATEGORY WINNER –
RAW ORE MATERIAL SIZER, NORTHWEST TERRITORIES**
Owner: Diavik Diamond Mines
Structural Engineer: SNC Lavalin Inc.
Steel Fabricator: Eskimo Steel Ltd.
Steel Detailer: Eskimo Steel Ltd. and M-Tec Drafting Ltd.
Steel Erector: Ledcor Industrial Ltd.

The judges commented that this project is an excellent example of what can be achieved through cooperative efforts from the designer and steel fabricator, while aiming to facilitate the strict demands of an aggressive construction schedule. Steel framing was the most intelligent material to use in this project as the team faced challenges of -55°C weather during installation, which eliminated the traditional requirements of hoarding and heating used for concrete placement and curing.



ONTARIO DESIGN AWARDS

**ENGINEERING CATEGORY WINNER –
ONTARIO COLLEGE OF ART & DESIGN (OCAD), TORONTO**
Owner: Ontario College of Art & Design
Architects: Robbie / Young + Wright Architects / Alsop Architects – Architects in Joint Venture
Structural Engineer: Carruthers & Wallace Limited
General Contractor: PCL Constructors Canada Inc.
CISC Fabricator, Detailer & Erector: Walters Inc.

The OCAD's bold and complex tabletop design was created to accommodate an expansion need, while addressing space limitations (a small parking lot) and stringent guidelines to avoid blocking view of green space to local residents. Twelve sloping steel columns are the primary support system for this structure, and steel's ability to span large lengths without temporary support made it the only building material that could accommodate this unique design.

**ENGINEERING CATEGORY HONOURABLE MENTION –
RICOH COLISEUM, TORONTO**
Owner: Board of Governors of Exhibition Place / Borealis Capital Corporation / Coliseum Renovation Corporation
Architects: Brisbin Brook Beynon Architects / Parkin Architects Limited
Structural Engineer: Yolles Partnership Inc.
General Contractor: PCL Constructors Canada Inc.
CISC Fabricator: Canam Steel Works,
Division of Canam Group Inc.
CISC Erector: Spark Steel Erectors Limited

**ARCHITECTURAL CATEGORY HONOURABLE MENTION -
NIAGARA FALLSVIEW CASINO & RESORT, NIAGARA FALLS**
Owner: Falls Management Company
Architects: Zeidler Partnership Architects / Bregman + Hamann Architects
Structural Engineer: Yolles Partnership Inc.
General Contractor: PCL Constructors Canada Inc.
CISC Fabricator and Detailer: Canam Steel Works,
Division of Canam Group Inc.
CISC Erector: Spark Steel Erectors Limited



QUÉBEC ONTARIO AWARDS

**COMMERCIAL AND INSTITUTIONAL CATEGORY WINNER ONE -
ÉCOLE NATIONALE DE CIRQUE**
Architect: Lapointe Magne et Associés
Structural Engineer: Dessau Soprin inc.
General Contractor: J.E. Verreault et Fils Itée
Owner: École nationale de cirque
Fabricator: Les Aciers Fax

The project features two large studios and stacked gymnasiums within a compact and vertical space. This approach strengthens the focus of the Cité des arts du cirque, reduces the footprint and exterior surfaces of the building, and optimizes the service distribution and energy consumption.

**COMMERCIAL AND INSTITUTIONAL CATEGORY WINNER TWO -
TRUDEAU INTERNATIONAL AIRPORT EXPANSION, PHASE 1**
Architect: Consortium PCJA: Provencher, Roy; Cardinal et Hardy; Jodoin Lamarre Pratte; Arcop
Structural Engineer: Consortium: SNC-Lavalin; Cima+
General Contractor: Consortium DVPT: Decarel; Verreault, Pomerleau, Tecsult
Owner: Aéroports de Montréal
Fabricator: Les Aciers Canam

The new construction included a transborder jetty and an international flights zone. The \$250 million project provided the Pierre-Elliott Trudeau airport with new and modern facilities while enhancing Montreal's dynamic and contemporary image.



**COMMERCIAL/INSTITUTIONAL CATEGORY HON. MENTION -
COLLÈGE NOTRE-DAME-DE-LOURDES EXPANSION**
Architect: Lemieux & Smith Vigeant architectes
Structural Engineer: Nicolet Chartrand Knoll Itée
General Contractor: Construction Yergeau Cart
Owner: Collège Notre-Dame-de-Lourdes
Fabricator: Les Structures Gialay inc.

**INDUSTRIAL AND BRIDGE CATEGORY WINNER -
ROND-POINT DE L'ACADIE RENOVATION**
Architect: Lemay et associés
Structural Engineer: Consortium: SNC-Lavalin; Dessau-Soprin
General Contractor: Construction Louisbourg
Owner: Quebec Ministry of Transportation
Fabricator: Les Constructions Beauce-Atlas (pont Ouest);
Structural - division de Le Groupe Canam Manac (pont Est)

Renovation of the Rond-point de l'Acadie into a true interchange will help alleviate the heavy traffic along that segment of the Metropolitan highway in Montreal. Among the project highlights are the two main steel plate-girder bridges sharply curved both in plan and in elevation.

**JUNIOR ARCHITECT/ENGINEER CATEGORY HON. MENTION -
CITÉ DES JEUNES DE RIVIÈRE-DU-LOUP STADIUM**
Junior Engineer: Sébastien Cinq-Mars, ing., GENIVAR Groupe Conseil inc.
Sponsor: Lucien Viel, ing., GENIVAR Groupe Conseil inc.
Fabricator: Jean-Pierre Belzile, ing., Les Structures GB Itée

**GREEN BUILDING CATEGORY WINNER -
TOHU PAVILION - LA CITÉ DES ARTS DU CIRQUE**
Architect: Consortium: Schème Consultants; l'architecte Jacques Plante; Jodoin, Lamarre, Pratte
Structural Engineer: Martoni, Cyr et Associés inc.
General Contractor: Construction Vergo
Owner: TOHU
Fabricator: Nico Métal
Detailer: Les Systèmes Datadraft, Dessins Cadmax

Designed to accommodate 840 spectators, this structural steel performance hall is unique in Canada and will soon receive the LEED™ "Gold" certification. The central lobby leads into an exhibition hall housing contemporary works of art related to the circus and environmental friendliness. The project incorporates recycled construction components such as steel beams from the former Angus factories.

**GREEN BUILDING CATEGORY HONOURABLE MENTION -
MOUNTAIN EQUIPMENT COOP DE MONTRÉAL STORE**
Architect: Consortium MTF
Architectes: Studio MMA; Lyse M. Tremblay architecte; Duschenes & Fish Architectes
Structural Engineer: Saia Deslauriers Kadanoff Leconte Brisebois Blais
General Contractor: Broccolini Construction
Owner: Mountain Equipment Coop (MEC)
Fabricator: Acier Métaux Spec, Les Aciers Canam

**PANEL'S CHOICE WINNER -
CDP CAPITAL CENTRE GLASS WALL**
Architect: Le Consortium: Gauthier, Daoust, Lestage; Faucher, Aubertin, Brodeur, Gauthier; Lemay & Associés
Structural Engineer: Le Consortium: Pasquin, St-Jean; Saia, Deslauriers, Kadanoff, Leconte, Brisebois, Blais; Le Groupe S.M.
General Contractor: Decarel Verreault Coentreprise
Owner: Société immobilière Camont inc.
Fabricator: Les Constructions Beauce-Atlas inc.
Erector: Montage d'Acier International inc.

The Caisse de Dépôt et Placement du Québec boasts a huge 40 x 100 m atrium enclosed by a magnificent glass wall and supported by a tree-shaped steel structure featuring steel castings for the joints.

**PANEL'S CHOICE HONOURABLE MENTION -
BERNARD LEMAIRE PARK KIOSK**
Architect: Bourassa et Gaudreau, architectes
Structural Engineer: Renaud Lapointe ingénieur
General Contractor, Owner and Fabricator: Cascades inc.

**PANEL'S CHOICE HONOURABLE MENTION -
HÔTEL-DIEU DE MONTRÉAL EMERGENCY ENTRANCE**
Architect: Yelle Maillé architectes associés
Structural Engineer: Saia Deslauriers Kadanoff Leconte Brisebois Blais
General Contractor: Construction Gesmonde Itée
Owner: Centre hospitalier de l'Université de Montréal (CHUM)



THANK YOU TO THE 2004 DESIGN AWARDS JUDGES

BC REGION

Dorothy Barkley, Architectural Institute of British Columbia
 Mark Thompson, Musson Cattell Mackey Partnership
 John Robertson, Westmar Consultants
 Garry Kirkham, BPA Group

ALBERTA REGION

Bob Kachuk, Supreme Steel Ltd.,
 Paul Collins, Collins Industries Ltd.; and
 Mike Payne, Waiward Steel Fabricators Ltd.

ONTARIO REGION

Dan Connolly, P.Eng., Kazmar Associates Limited
 Lloyd Hilgers, Principal, Murphy Hilgers Architects Inc

Scot McCavour, P.Eng., McCavour Engineering Limited
 Terry Montgomery, Principal, Montgomery Sisam Architects Inc.
 Bruce Neil, P.Eng., Adjeleian Allen Rubeli Ltd.
 Thomas Payne, Partner, Kuwabara Payne McKenna
 Blumberg Architects
 Don Turner, Moderator

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 François Jutras (Roche Itée Groupe Conseil)
 Odette Roy (Les architectes Odette Roy et Isabelle Jacques)
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- Prebilt Structures Ltd. S,P
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- Acier Métaux Spec inc. S
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www.metauxspec.com
- Acier Robel inc. S
St-Eustache, Québec (450) 623-8449
- Acier Trimax Inc. S
Ste-Marie, Beauce, Québec (418) 387-7798
www.trimaxsteel.com
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Terrebonne, Québec (450) 965-1911
www.adfgroup.com
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- Constructions PROCO Inc. S
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www.proco.ca
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www.canatal.net
- Jean-Yves Fortin Soudure Inc. S
Montmagny, Québec (418) 248-7904
- Les Aciers Canam, S,J
division de Groupe Canam Inc.
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* Sainte-Foy, Québec (418) 652-8031
www.canam.ws
- Les Aciers Fax Inc. S
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www.sofab.ca
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www.structurescdl.com
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- Les Structures Gialay Inc. S
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www.locweld.com
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www.nico-metal.com
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www.deltajoists.com
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- Sturo Métal Inc. S
Levis, Québec (418) 833-2107
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- ACL Steel Ltd. S
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www.aclsteel.ca
- * ADF Steel Corp. (Canada S
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- Benson Steel Limited S,J
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Weldfab Limited Saskatoon, SK www.weldfabltd.com	S	(306) 955-4425

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* Canam Steel Works, Division of Canam Group Inc. Edmonton, Alberta www.canam.ws	J	(780) 464-0435
C.W. Carry (1967) Ltd. Edmonton, Alberta www.cwcarry.com	S,P	(780) 465-0381
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Western Steel Fabricators Alberta Ltd. Edmonton, Alberta www.westernsteel.ca	S	(780) 436-4656
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Empire Iron Works Ltd. Delta, B.C. www.empireiron.com	S	(604) 946-5515
J.P. Metal Masters Inc. Maple Ridge, B.C. www.jpmetalmasters.com	S	(604) 465-8933
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www.vicwest.com
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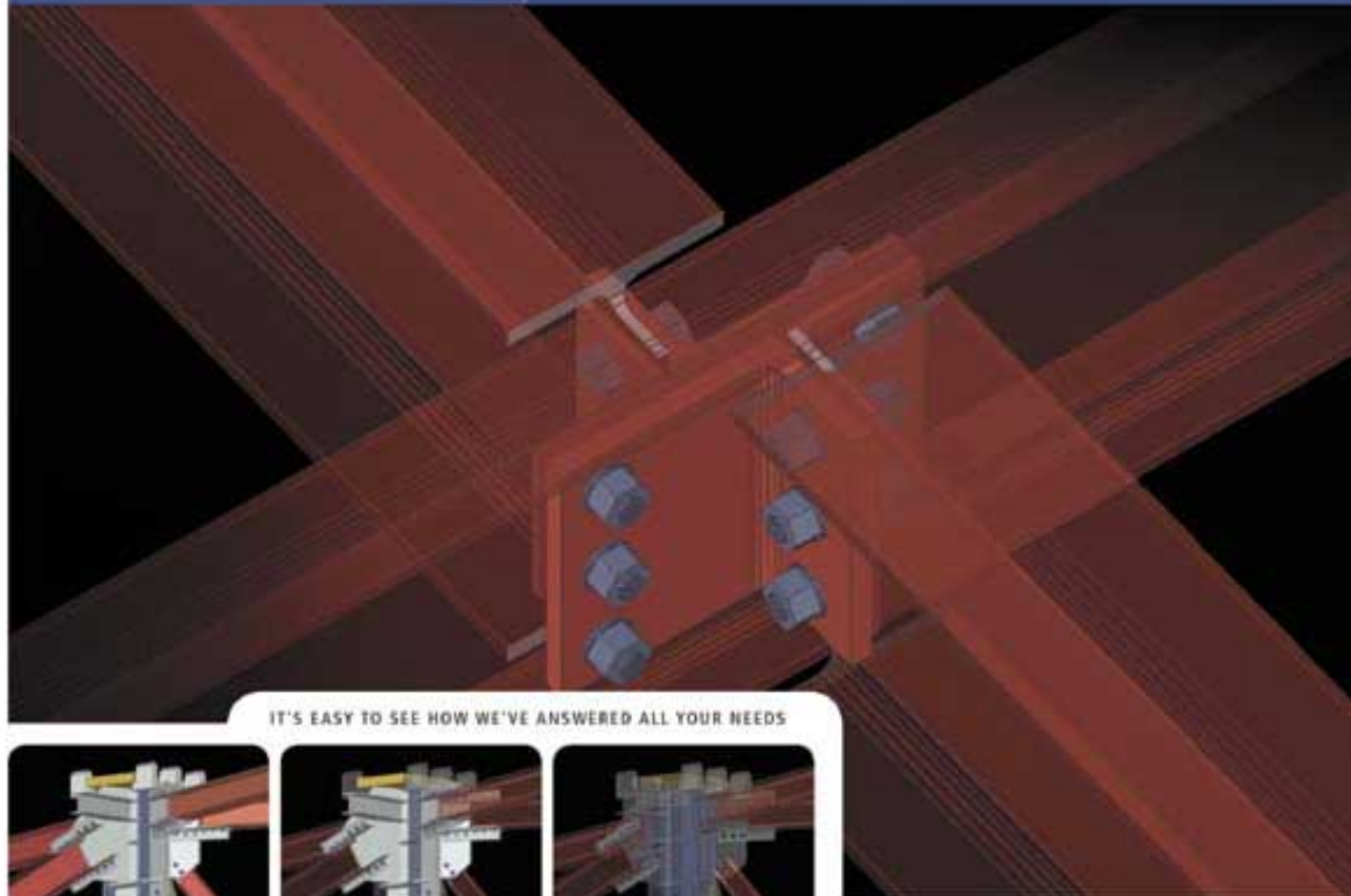
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ROLLING SCHEDULE						
WEEK A	WEEK B	WEEK C	WEEK D	WEEK E	WEEK F	WEEK G
12X4	10X8	10X6	10.75RD	16.0RD	10X10	14.0RD
8X8	14X4	12X4				
	12X6	8X8	10X8	10X6	10.75RD	10X6
9.625RD			14X4	12X4		12X4
	12.75RD	9.625RD	12X6	8X8	10X8	8X8
8X6					14X4	
7X7	16X8	8X6	12.75RD	9.625RD	12X6	9.625RD
	18X6	7X7				
12X8	20X4		16X8	8X6	12.75RD	8X6
14X6	14X10	12X8	18X6	7X7		7X7
16X4	12X12	14X6	20X4		16X8	
10X10		16X4	14X10	12X8	18X6	12X8
	14.0RD	10X10	12X12	14X6	20X4	14X6
10.75RD				16X4	14X10	16X4
					12X12	

Add two days for heat treating on above rolling schedule



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