ADVANTAGE STEEL

NO. 60 WINTER 2018

EDUCATION & RESEARCH ISSUE

A REPLACEABLE BRACE MODULE FOR SEISMICALLY DESIGNED FRAMES

LEADING ENGINEERING SCHOOLS FACE-OFF AT THE CANADIAN STEEL BRIDGE COMPETITION

ASSEMBLAGE

EXCITING NEW TRAINING PROGRAMS IN THE WORKS!

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ADVANTAGE STEEL

NO. 60 WINTER 2018

FEATURES

IN EVERY ISSUE

COLUMNS

The Canadian Institute of Steel Construction (CISC) is the Voice for the Canadian Steel Construction industry. The CISC represents a diverse community of structural steel industry stakeholders including manufacturers, fabricators, erectors, service centres, consultants, detailers, industry suppliers, owners and developers. Steel construction industry stakeholders are encouraged to apply to become a member or associate. Visit cisc-icca.ca for more information. If you are working on a project that you think should be featured, send us an email at ciscmarketing@cisc-icca.ca.

On the Cover: The 2016-17 winner of the Architectural Student Design Award of Excellence - "This Is Not A Bridge"

Ed Whalen, P.Eng.
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/cisc_icca

Winners and Losers of Ontario's New Prompt Payment Legislation

Winners: Ontario Construction companies reliant on payment as per contract. In December, the province of Ontario passed prompt payment legislation that finally brings Ontario construction payment in line with the rest of the western world and possibly better. Ontario's Bill 142, the *Construction Lien Amendment Act*, which received Royal Assent in December, provides much needed updates to the *Lien Act* and more importantly introduces Prompt Payment Legislation.

Losers: Those profiting from lien action. With this new legislation, the need and impact of a lien is now substantially reduced. With the Prompt Payment rules, a trade contractor will be able to reduce their financial exposure to one payment rather than the multiples in today's world. Liens applied will now be applicable to a smaller amount of money, depending on the duration of the project, and will have less impact on the recipient's ability to survive than it does today.

Winners: Companies, employees and their families, unions and pension funds. Unlike today, when companies are driven to bankruptcy due to illegal and intentional withholding of payment, companies will have the ability to demand and obtain payment as per their contract or withdraw services and supply. The working middle class will now have better job security and companies can now focus on doing great work rather than fighting for payment.

Losers: Owners and general contractors that used payment delay as a method to improve their own profitability at the expense of the contractors that worked for them.

Winners: The trade contractors, their representative associations and the National Trade Contractors Coalition of Canada (NTCCC). Construction payment corruption has galvanized the trades, their associations and more importantly the entire trade contractor community under the brand of NTCCC. The NTCCC has clearly championed and achieved success for the interests of the trades that no other construction association was willing to do. The NTCCC will continue to fight for Prompt Payment legislation until the last jurisdiction has passed it into law.

Losers: Litigation lawyers. Oh yes, there will always be disputes and with the drawings as bad and margins as tight as they are these days, you could argue that litigation could be and will be as strong and as prevalent as ever. One thing for sure, the amount of litigation on non-payment will be substantially reduced.

Winners: Construction Dispute Adjudicators. The new legislation introduces the process of adjudication. This time fixed process, which was copied from the British system, will rely on a pool of expert construction adjudicators. Since we do not have this pool of experts set up to date nor do we have the exact details on how the process will work, the Ontario government has stated that the time to implement Prompt Payment will be approximately 18 months from now. Maybe the lawyers see some work as adjudicators but expect to see some competition from the real experts…. people like you possibly. Think about it.

Losers: Those that are in desperate need of Prompt Payment today. As mentioned, prompt payment provisions will take approximately 18 months to fully implement. Expect the Lien reforms to take effect within six months or mid 2018. At the time of this writing, many of the provinces have shown signs of using the Ontario model as a template and enacting their own legislation. This will take several years for this to spread across the country.

Winners: The General Contractors were able to have the concept of "right to contract" included in the prompt payment legislation. This means that the GC or owner can deviate from the default payment terms mentioned in the legislation, extending the payment period to whatever they want. If you are willing to sign this then you are bound by the contract you sign waiving some or all of the provisions we have been fighting so hard for.

Losers: Those that do not read their construction contract carefully before signing. The "right to contract" will allow new and interesting contract provisions to be binding. If you sign the contract without fully reading and understanding your risks, well…I think we have enough experience to know now what the possible outcomes could be by now. When in doubt, have your lawyer have a look!

Winners: Downstream suppliers and trades. Prompt payment legislation will require payment to be made on a timely basis right down the entire construction food chain.

Losers: Canadian Construction Association and Local Construction Associations. The inability for some local construction associations to fight for their membership majority (i.e. the trades) for fear of alienating the GCs was and is interesting to watch. In a time where associations need to be showing, even more than before, value for their members the Prompt Payment wedge issue was the perfect storm that, in my opinion, may have set in motion the beginning of the end for some. Even more evident and obvious was CCA. Clearly driven by the GCs, they waffled, dragged their heels, and even behind the scenes advocated against legislation. Ultimately the group they tried to please the most is now rumored to be setting up a national association of general contractors. If the CCA turned their backs on the trades, and now the GCs turn on the CCA, it clearly will no longer be able to claim it is the voice of the construction industry in Canada. It seems like the days of contracts that are never used as originally drafted and guidance documents that are written that are never followed will come to an end. AS

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Charles Albert, P.Eng.
Manager of Technical Publications and Services

Question 1: What value of "n" should be used to design columns made of three-plate welded sections?

Answer: The answer depends on how the section was fabricated. According to CSA S16-14 Clause 13.3.1, n = 1.34 for fabricated structural sections in general. But if the flange edges of a doubly-symmetric member are oxy-flame-cut, then n = 2.24 because of the favourable residual stress pattern. The higher value also applies to HSS produced to CSA G40.20 Class H (hot-formed or cold-formed stress-relieved). Both column curves are illustrated in Figure 1.

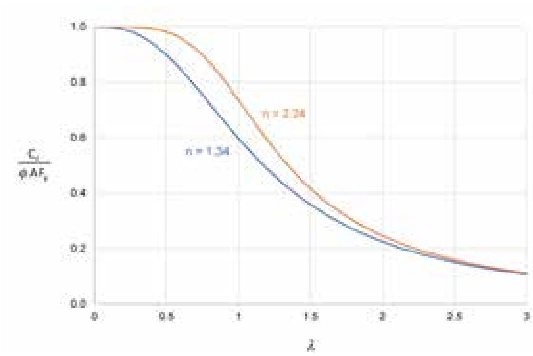


FIGURE 1
Column Curves

Question 2: Do direct tension indicator bolts require hardened washers?

Answer: When high-strength bolts are pretensioned, ASTM F436 hardened washers must be placed under the turned element when using ASTM F959 direct tension indicators (S16-14 Clause 23.4.2(b)). An F959 washer is illustrated in Figure 2. The reason for this requirement is to ensure that the protrusions of the F959 washer bear against a hardened surface, and to prevent the protrusions from wearing down by scouring.

FIGURE 2
Direct Tension Indicator

As mentioned above, this requirement applies to hardened washers placed under the turned element (Clause 23.4.1). Standard washers are not required when F959 washers are placed against the underside of the bolt head if the head is not turned.

Question 3: What is the matching welding electrode for 350W steel?

Answer: Most welded applications involve matching electrodes, such that the ultimate tensile strength of the electrode (X_u) is similar to that of the base metal (F_u). An over-matched electrode, for example, is one designation higher than matching.

Matching electrode classifications for CSA G40.21 steels are listed in S16-14 Table 4. For 350W steel, the matching electrode ultimate tensile strength is X_u = 490 MPa.

Also refer to the Technical Column in *Advantage Steel* No. 54 and 57, and to CSA W59, for further information on the use of over-matched and under-matched electrodes. AS

Most welded applications involve matching electrodes, such that the ultimate tensile strength of the electrode (X_u) is similar to that of the base metal (F_u).

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

Michel Bruneau
University at Buffalo
Buffalo, NY, USA

Greg MacRae
University of Canterbury,
Christchurch, New Zealand

A Seismic Shift to Structural Steel

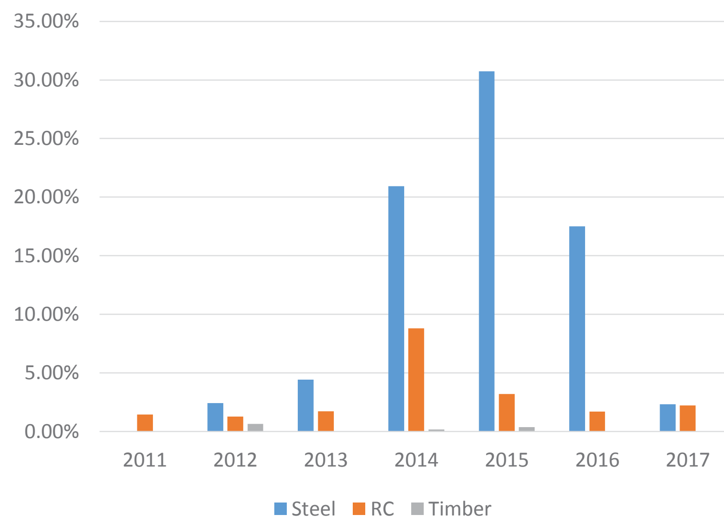
AFTER THE 2010–2011 Canterbury earthquakes, much of the Christchurch Central Business District (CBD) was demolished, and a new city has emerged in its place. From a structural engineering perspective, the new "heart" of Christchurch is quite different from the old one. Where reinforced concrete buildings dominated the urban landscape, with almost all multi-storey buildings relying on RC frames or walls to resist earthquake shaking, the emerging Christchurch has a variety of structural forms, an extensive amount of steel structures, and some structural systems introduced to make the new Christchurch buildings more seismically resilient. In fact, as part of the reconstruction, structural steel has been used in the lateral resisting system of about half of the buildings. However, because it has been used in the larger structures, buildings with steel lateral force resisting systems account for 80% of the total square footage for all new construction, as shown in Figure 1. Also, in about 75% of the concrete structures, steel is used for the gravity flooring system. As a result, structural steel is used in about 88% of all buildings, or 95% of the supported floor areas rely on steel framing.

This is extensively documented in the report Reconstructing Christchurch: A Seismic Shift in Building Structural Systems, recently published by the Quake Centre headquartered at the University of Canterbury. The free report is available at http://resources.quakecentre.co.nz/reconstructing-christchurch. This study was conducted to (a) quantify the extent to which various types of structural systems have been

used in the new buildings constructed (for data collected up to March 2017), and (b) identify some of the drivers that have influenced decisions about the selection of structural material and specific structural systems used. The study involved a series of interviews with the structural designers of more than 60% of the post-earthquake buildings constructed to date in Christchurch's CBD (i.e., 74 buildings), as well as with engineers from Wellington and Auckland, an architect, a project manager, and a developer. Data was also collected from various sources (including Christchurch's City Council database), and quantitative information on structural forms and decision drivers has been assembled for the 74 buildings considered.

The report also documents the number and square footage of buildings using the various structural systems used as part of this reconstruction, such as base isolation, viscous dampers, buckling restrained braces, eccentrically braced frames, concentrically braced frames, moment resisting frames, concrete walls, and others. As such, on the strength of this quantitative data and the perspectives on decision making provided by the interviews, this report provides valuable insights into some of the mechanisms that can dictate structural engineering decisions during the post-earthquake reconstruction of a modern city. The Christchurch experience may be unique today, but it could repeat itself in other similarly developed cities worldwide after future devastating earthquakes. AS

(A)



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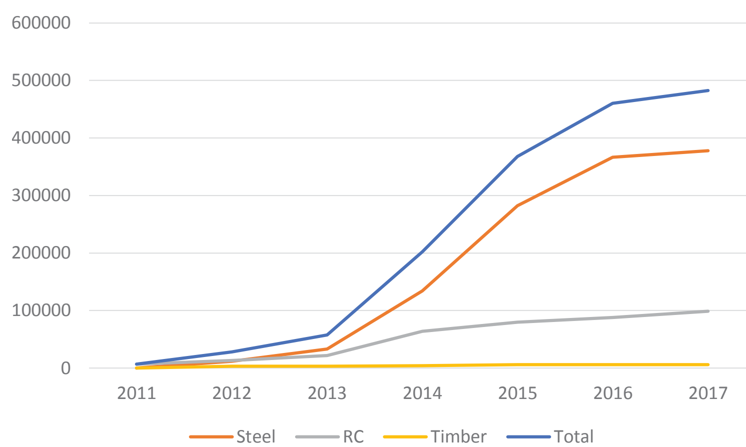
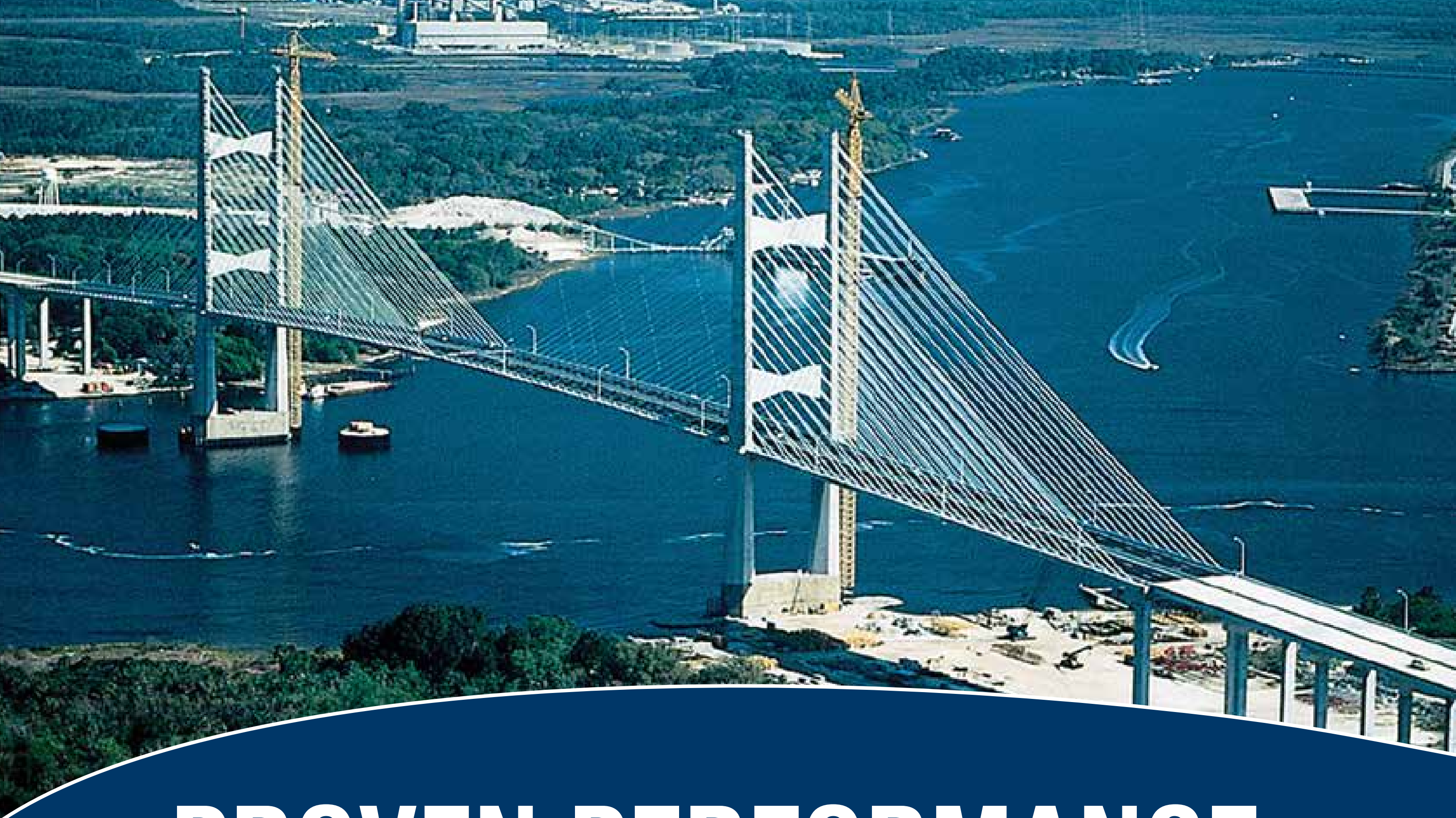


FIGURE 1: Floor area of new buildings having lateral-load resisting systems of each material type: (a) Percentages; (b) Cumulative numbers (from *Reconstructing Christchurch: A Seismic Shift in Building Structural Systems)*



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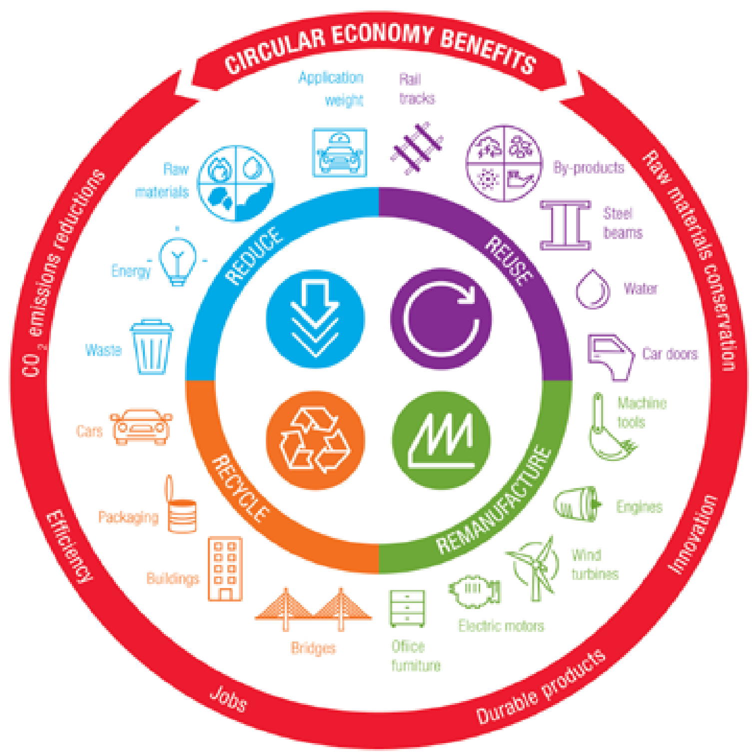
Tareq Ali, RPM
Director of Marketing and Communications

Steel in the Circular Economy

A circular economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. This is in contrast to a linear economy which is a 'take, make, dispose' model of production. -Wikipedia



source: worldsteel.org

A CIRCULAR ECONOMY ensures that value is maintained within a product when it reaches the end of its useful life while at the same time reducing or eliminating waste. This idea is fundamental to the triple-bottom-line concept of sustainability, which focuses on the interplay between environmental, social and economic factors. In a well-structured circular economy, the steel industry has significant competitive advantages over competing materials. The Three Rs of steel capture why it is the most sustainable and resilient building material on the planet:

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- Approximately 90% of North American structural steel is produced using the mini-mill Electric Arc Furnace (EAF) which relies on virtually 100% recycled steel.

2. REUSE:

- Because of its durability, steel can be reused or repurposed in many ways, with or without remanufacturing.
- Designers reuse elements of a steel structure onsite or have them dismantled and rebuilt elsewhere without loss of steel's basic properties.
- Slag, a byproduct of steel, is fully recovered and reused for road building, cement substitutes and other applications.
- Gases produced during iron making are reused for reheating.

3. RECYCLE:

- Steel is 100% recyclable and can be recycled over and over again to create new steel products in a closed material loop.
- More steel is recycled each year than paper, aluminum, glass and plastic combined.
- Of the 99% steel recovered at the end-of-life of a steel building, 15% is locally reused and the rest is recycled
- Recycled steel maintains the inherent properties of the original steel. The magnetic property of steel ensures easy and affordable recovery for recycling from almost any waste stream while the high value of steel scrap guarantees the economic viability of recycling.
- Today, steel is the most recycled material in the world. Over 650 Mt of steel is recycled annually including pre- and post-consumer scrap. The steel industry continues to further integrate these advantages into its operations in order to highlight the benefits of steel to those people making decisions on material choices.

REMANUFACTURE:

- Remanufacture involves the disassembly of a product, during which each component is thoroughly cleaned, examined for damage, and either reconditioned to original specifications or replaced with a new or upgraded part.
- The product is then reassembled and tested to ensure proper operation.
- Many steel products such as construction and farm machinery, truck and car engines, electrical motors, domestic appliances, and wind turbines are already remanufactured.
- Remanufacturing takes advantage of the durability of steel components. Once recertified, the application is then 'as-new' and can continue to be utilized for longer. AS

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A REPLACEABLE BRACE M
DESIGNED FRAMES

ODULE FOR SEISMICALLY

By Lydell Wiebe, Assistant Professor, Daniel Stevens, MASc Graduate,
Vahid Mohsenzadeh, PhD Candidate

MANY PEOPLE assume that modern buildings are earthquake-proof. However, recent earthquakes in the developed world have clearly demonstrated the destructive power of earthquakes. Even when the lives of building users are saved, earthquake damage can prevent a building from being used for many months, if the building can be repaired at all.

In Canada, one of the most common seismic force resisting systems for steel buildings is a concentrically braced frame, shown in Figure 1. During an earthquake, the braces are designed to buckle in compression and yield in tension. While this would not be acceptable during a wind storm, it is what allows steel structures to be designed with competitive initial construction costs while also ensuring the safety of building users during an earthquake.

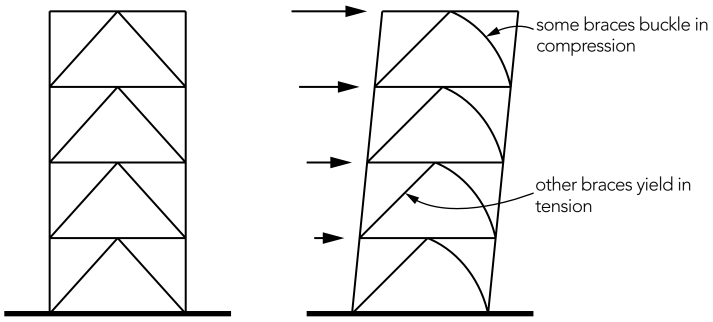
To harness the strength and ductility of steel braces, special seismic detailing is required to develop the full tensile capacity of the brace and accommodate brace buckling. This detail requires field welding of the brace to the gusset plate, which is expensive and complicates quality control.

In addition to the problems of field welding, current seismic design practice causes the braces to buckle out of plane during an earthquake. This is likely to push the wall off of an exterior frame, endangering the lives of anyone in the area of the falling debris.

Moreover, when a significant earthquake occurs, the rotation at the end of the brace causes permanent damage to the gusset plate. Testing has shown that yielding can also extend into the adjacent beam and column. This damage is likely to be difficult or impossible to repair.

At McMaster University, a team of seismic researchers is looking to address this problem by exploring a new connection design that:

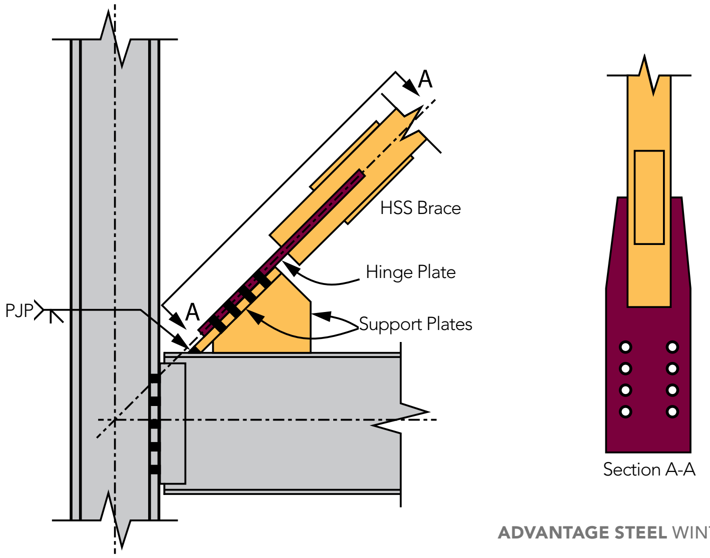
FIGURE 1: Concentrically braced frame



1. increases erection speed and reduces erection cost by avoiding field welding,
2. enhances earthquake safety by preventing loss of cladding caused by out-of-plane buckling,
3. reduces the cost and time of post-earthquake repairs by confining damage to a replaceable brace module, and
4. meets or exceeds the cyclic loading performance of current best practices.

Figure 2 shows the new connection design that was developed. In this concept, the plate that is slotted into the brace allows rotation in the plane of the braced frame, avoiding the damage that is caused by out-of-plane buckling. Furthermore, by avoiding a gusset plate altogether, this concept confines the expected damage to the brace module that is bolted into position, allowing the module to be unbolted and

FIGURE 2: New replaceable brace module connection



> All eight of the braces that were tested performed as intended, yielding at the centre and ends of the replaceable brace module under the loads that would be expected during an earthquake.

replaced after an earthquake without affecting the rest of the structure.

TESTING AT MCMASTER UNIVERSITY

With the support of the CISC, local fabricator Walters Group, and the federal and provincial governments, an experimental testing program was performed to assess the connection's behaviour. Eight brace modules were tested, each at 3/4 scale relative to a reference structure that was designed for Vancouver, B.C. Figure 3 summarizes the test setup.

All eight of the braces that were tested performed as intended, yielding at the centre and ends of the replaceable brace module under the loads that would be expected during an earthquake, and withstanding repeated large loading cycles before eventual fracture in the brace. The regions outside of the brace module had no observable damage, even after being used for several tests. The drift ranges that the brace modules could withstand were similar to what braces with seismically detailed connections have endured in previous studies. In addition, the brace performance was primarily influenced by the brace shape, rather than the connection parameters, confirming an equivalent level of performance compared to existing seismic details.

Although the connection shown in Figure 2 had some eccentricity, this did not result in any undesirable yielding or failure. Similarly, although the connections were not designed as slip-critical, bolt slip had little effect on the overall brace module performance. This was because, after the brace had buckled, its compressive capacity became less than the slip load of the connection.

An alternative connection, with the bolts in double shear, was also tested. However, the performance of the single-shear connection was equal to or better than that of the double-shear connection, with no observed negatives associated with the eccentricity in the connection and less risk of early connection failure. For these reasons, together with the improved constructability of a single splice connection, the single-shear connection is the preferred choice for further development as an alternative connection for concentrically braced frames.

NEXT STEPS

This testing demonstrates that the brace module behaves as intended, achieving the same level of

FIGURE 3: Testing of replaceable brace module at McMaster University

performance as more conventional brace details, while confining damage to the replaceable module. These results were presented at the Canadian Society for Civil Engineering Annual Conference in 2016 and at the World Conference on Earthquake Engineering in 2017, and they are also the subject of a journal paper in the *Journal of Structural Engineering*. The next step in this ongoing research is to demonstrate that this replaceable brace module will function as intended as part of an overall building system, considering its interaction with beams and columns.

Implementing this replaceable brace module is expected to make steel more competitive in seismic regions of Canada through savings in erection time and cost. In addition, when the next major earthquake strikes, this detail is expected to reduce the likelihood of falling cladding and to simplify post-earthquake repairs, thus saving lives, time, and money. AS

FEATURE

LEADING ENGINEERING SCHOOLS STEEL BRIDGE COMPETITION

Bridge competition continues to offer challenges . . . and benefits

By James Peters

FACE-OFF AT THE CANADIAN

Esprit de corps (noun): A feeling of pride, fellowship and common loyalty shared by members of a particular group.

WITH THE SECOND ANNUAL Canadian National Steel Bridge Competition (CNSBC) wrapped up earlier this year, engineering students from across Canada are already preparing for the third event in 2018—to be held once again in May but this time at the University of Waterloo. The first competition took place at the organizers' home university at McGill University in Montreal and the second at Université Laval in Quebec City.

The competition challenges students to participate in a project that involves concept, design, fabrication, erection and testing of a steel bridge structure—all conforming to the event's specifications while optimizing performance and economy. Eight teams participated at the 2017 event, including École de Technologie Supérieure (first place), École Polytechnique de Montréal (second place), University of British Columbia (third place), University of Waterloo,

Université Laval, University of New Brunswick, University of Toronto and McGill University.

The competition was formed through a partnership between the Canadian Institute of Steel Construction (CISC) and the Canadian Society for Civil Engineering. Co-creator Éric Lachance-Tremblay explains, "Back in 2014, Jean-Luc Martel and I came up with the idea of providing Canadian students with a Canadian alternative to the American Institute of Steel Construction/American Society of Civil Engineers National Student Steel Bridge Competition—a very well-known event in the United States. Although our local team participated in the U.S. competitions, we knew that students from other universities across Canada often didn't—sometimes because of budgetary restraints but for other reasons as well." In spite of a few differences, the Canadian competition is still modelled after the AISC/ASCE event—with modifications that allow participating students to use their bridge design in both.

"I think the general public doesn't usually consider structural engineering as being overly artistic—but I've been awestruck by the beauty and creativity of these bridge designs."

Mark Bruder, Head Judge

One of the main differences between the American and Canadian contests is the emphasis on aesthetics. As many observers from the Canadian side will tell you, the greater emphasis on design points only enhances the event's atmosphere. Structural engineer Mark Bruder, who's been the head judge of the competition from the very beginning, says, "I think the general public doesn't usually consider structural engineering as being overly artistic—but I've been awestruck by the beauty and creativity of these bridge designs. And, of course, the competition increases the students' awareness of real-world engineering issues."

It was originally through the concrete canoe competition that Bruder, an associate with R.V. Anderson Associates Ltd. in Toronto, got involved.

Success in competition requires the application of engineering principles and theory, and effective teamwork. Future engineers are stimulated to innovate, practice professionalism and use structural steel efficiently.

"More than half of the points allotted in this are prescriptive with little room for subjectivity. In the U.S. there are literally hundreds of competitors, so even dropping a nut during the assembly can cost you points and a spot on the podium. But because the Canadian event incorporates a design aesthetic representing a third of the overall mark, that's clearly in the forefront of the competitors' minds. They know going in that they have to emphasize the design aspect as well as building the most efficient bridge possible," says Bruder.

In the competition, the bridges are built to scale at roughly a 1:10 ratio. For the second year in a row, the parameters were based on building a bridge over an imaginary river where the footings were critical. As to be expected, there are strict guidelines as to length, height, width and a multitude of other engineering criteria. It's equally important that the contestants use steel for construction for all of its many virtues—strength, safety, durability, versatility, resilience and cost-effectiveness. And from an aesthetic or architectural viewpoint, steel structures can easily deliver creative design options while still offering excellent value.

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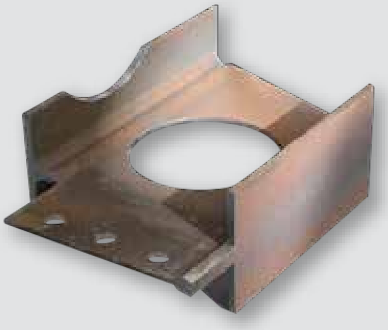

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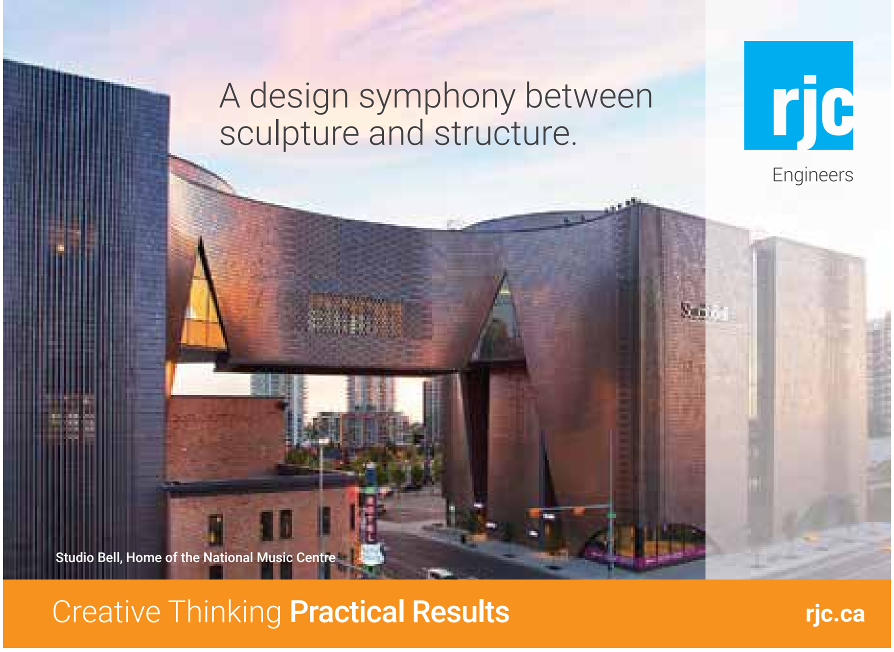

Bruder says, "There's usually a very explicit problem statement for the contest that includes a description for the river, its depth and where it crosses. With a departure from the first competition, the participants in 2017 had the option of designing the piers as fixed or with one allowed to be a cantilever. Bruder adds, "You could build either one of these scenarios and every single group decided on the cantilever. We were all pleasantly surprised."

As stated in the criteria and contest rules, the purpose of the competition is to increase awareness of real-world engineering issues such as spatial constraints, material properties, strength, serviceability, fabrication and erection processes, safety, aesthetics, project management and costs. Success in competition requires the application of engineering principles and theory, and effective teamwork. Future engineers are stimulated to innovate, practice professionalism and use structural steel efficiently.

Martel adds, "The various categories include design aesthetics, an effective oral presentation, construction speed, lightness, stiffness, construction economy and structural efficiency. The overall winning team is the one with the highest overall score."

Throughout the process, students design and erect the steel bridge by themselves but may consult with faculty and other advisors. Although they gain maximum benefit if they fabricate the entire bridge, it's understood that shop facilities and supervision are not available at all universities so they can use the services of a commercial fabricator if they develop the work orders and shop drawings, and observe the operations. At all times, of course, safety is paramount.

Bruder says, "What I've witnessed is just how many of these students are interested in building bridges. Although I want to act as a mentor during the competition, as a judge you have to make some pretty difficult decisions and stay at arms-length to remain unbiased."

The competition is essentially the same from year to year, with one important change from the inaugural

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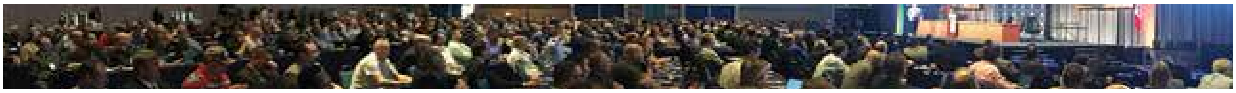

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"I gain a lot from other contractor and labor organizations, and that's the beauty of this conference. We all come together, share our experiences – good and bad – and learn from those and become better."
- Chris Buckman, VP of Corporate Construction, BMWC Constructors, Inc.

"The leaders come to this conference, so if you want to be in a room full of leaders, this is the room to be in."
- Jim Kanerva, Chief Operating Officer, Waiward Steel

event. The first time around the entire event took place over one day, which was simply too compressed. Students had to set up the bridges for viewing and judging for aesthetics and then take them down, bring them across to the assembly hall and set them back up again to do the load test. So starting with the 2017 event, the competition has been stretched over two days. In addition to giving the students more time, it also provided more breathing room for the judges and organizing committee.

Bruder concludes, "I've been amazed at the positive vibe this competition has created, with full kudos to Éric and Jean-Luc for bringing the idea onto the Canadian scene. Since graduating from university, I don't often get to spend a lot of quality time with engineering students. What I've learned from this competition is that most students are very mature, creative and intelligent—with a great work ethic and fierce determination to do well in the event. It's very reassuring to know that these are the people who will be running our companies, making decisions and designing our infrastructure. They've chosen to do this above and beyond their studies and they continually push themselves.

And what do the students gain?

Lachance-Tremblay says, "We gain real world experience in terms of constraints, such as building within a budget and on deadline. Textbook answers are simply not the same as real world applications. And another reason? Some of the students dress up and cheer each other on—yelling words of encouragement from the sidelines. And it's fun!" AS


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ASSEMBLAGE:

The 2016-17 Architectural Student Design Competition

By Loraine Fowlow, B.Sc. (Civil Eng), M.E.Des. (Arch), MRAIC

THE 16TH YEAR of this annual competition focused on the question of Assemblage, a term that is used here to refer to design at the scale of connections, both cultural and physical. The intention was to challenge architecture students to explore what it means to connect, in terms of design context and structure. From a composition perspective, it can refer to text that is "built primarily and explicitly from existing texts to solve a writing or communication problem in a new context." Within an architectural context, Pamela Popeson of the MoMA refers to assemblage as an architectural tool that "offers a dynamic, inventive connection to cultural context."

In terms of this competition, Assemblage was an invitation for students to explore architectural connections, be they connections between context and structure, or the connections that allow an assemblage of materials and structural elements to come together to form a structural whole. In that sense, the 2016-2017 CISC Architectural Design Competition invited students to explore the utilization of steel as the primary structural element that makes an assemblage possible. Students were challenged to design a structure that explores assemblage on a site of the designers' choosing. While the purpose and scale were left to the discretion of the designer(s), it was important to focus on what it means for us to engage and experience Assemblage.

While this challenge might seem to be obscure, 43 teams of students and their faculty advisors rose to the challenge with imaginative, inventive, and well-considered design schemes that amply fulfilled the competition's mandate.

The jury had a very difficult task in choosing which three entries to recognize with awards, and which of the three to award the top prize. Many thanks to the jury for meeting this daunting challenge: Chris Graczyk, Senior Modeler, Walters Group, Hamilton; Holly Jordan, Senior Associate, B+H Architects, Toronto; Kris Lima, Senior Structural Engineer & Project Leader, Dialog, Edmonton; Loraine Fowlow, Associate Professor of Architecture, University of Calgary.

It must also be noted that this year's competition saw yet another record (double) win by University of Waterloo professor Terri Meyer Boake. Terri's students have won, or placed in every single year of the CISC Architectural Student Competition, which is a remarkable record of achievement. The secret of her success was outlined in an Advantage Steel article written by Terri in the Winter 2015/16 Education and Research issue, which is an excellent and informative explanation of how she manages to cultivate the production of winning student designs.

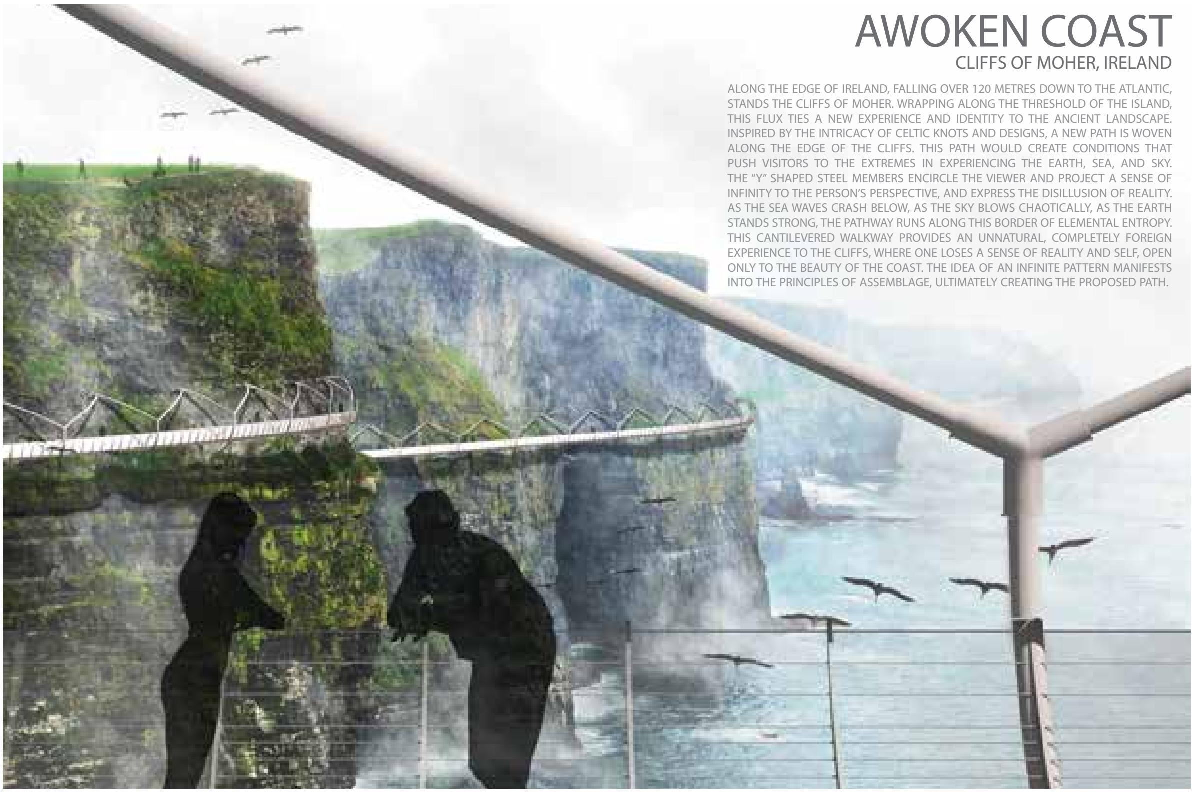
Congratulations to this year's award winners and their faculty advisors for producing such fantastically creative design in steel!

AWARD OF EXCELLENCE: "This is Not a Bridge"
Bennett Oh, Nathanael Scheffler & Darien Boodan
University of Waterloo
Faculty Advisor: Terri Meyer Boake

AWARD OF EXCELLENCE: "THIS IS NOT A BRIDGE"

This political statement in the form of a bridge spanning the Demilitarized Zone in Korea cleverly confounds the usual expectation of what it means to span: the two halves of the bridge do not actually meet in the middle of the span. In other words, this design physically manifests a political idea as its conceptual approach. This very unusual approach to designing a bridge meant a re-think of the structure. The students write:

"The form of our project necessitates that the two halves are separate, which means that they cannot rely on each other for support. The design of the masts allows the two halves to act individually, but also be very close. The masts are pinned connections to make it possible to adjust the distance of the gap during construction. They support the bridge deck



AWARD OF MERIT: "Awoken Coast"
Meaghan McKinley, Nick Makhalik & Tracey Elasmar
University of Waterloo
Faculty Advisor: Terri Meyer Boake

via tension cables and they are tied back through larger tension cables to the large concrete foundations at the entrance to bridge decks.

To reduce the required capacity of the masts the bridge deck is designed to be as light as possible. The structure is made up of a tension/compression separated truss. The tension members are made of thin cables and the compression members are placed only where necessary. This allows the decking structure to be very transparent, which in combination with the glass decking accentuates the precarious nature of the space. Another difficulty in the construction of this project would be that it would have to be built from each side. The deck is designed in modules that fit in structural rails to make this easier."

AWARD OF MERIT: "AWOKEN COAST"

The structural approach to this precarious, suspended cliffside walkway in Ireland is clever yet simple. The students write:

"Due to difficulties of assembly on site, the cliff walk is designed in 5m x 10m modules that can be assembled off site and are small enough to be shipped to site by road or water. The module's structure consists of: the Y-shaped round HSS members that connect at the centre through a bolted casting member. A casting was chosen over a welded connection for added strength. An angled rectangular steel HSS member is attached to the round HSS through the use of plate connection pieces that are welded or bolted to their respective pieces. It spans 5m in each direction where it connects to the next module. A rectangular HSS member was chosen instead of a C-section to better resist

AWARD OF MERIT: "Pier 365"
Tatiana Estrina & Martina Cepic
Ryerson University
Faculty Advisor: Vincent Hui

torque. 1.2m cantilevered wide flange angles are bolted to the HSS and are the main support for the walkway. And finally, a central T-section is welded to the wide flanges for additional support of the walkway. Other details include a glass floor and railing system, a small tension detail between the centre and end wide flanges, and a steel plate and wire railing system for the outer edge."

AWARD OF MERIT: "PIER 365"

This redevelopment of a boardwalk along the Rideau Canal aims to provide visitors with an integrative experience of the waterfront. What is unique about this design is the responsiveness of the structure to its environment. The students write:

"To assemble is to unify and connect a series of things, whether it be people or objects. Pier365 is a re-development of the boardwalk, providing a new set of possibilities of programmatic use, the gathering of people, and amalgamation of Ottawa's breathtaking views by the changing of site variables. Through the use of kinetic steel assemblies, this urban intervention responds to changes in its environment, providing visitors to the Rideau Canal new levels of engagement and experience throughout the year.

"In the summer months, due to the water levels rising, the structure is able to expand out into the water. This allows users to interact with the canal on a different, more intimate level, as well as providing docking mechanisms for canoes and kayaks. The canopy is expanded to hover over the structure to provide shade from the hot summer sun, while also acting as a light source.

In the winter the structure is rearranged into a more compressed state that mimics stadium seating. Many events are held on Dow's Lake in the winter, so the structure provides a seating arrangement for audiences. There are also two staircases that descend towards the ice which give skaters direct access to the frozen lake." AS

Exciting New Training Programs in the Works!

By R. Mark Lasby, P. Eng., Manager of Education and Research

IN THE PAST 10 YEARS, CISC's continuing education programs have shifted from technical, design oriented courses for consulting structural engineers to education and training for numerous stakeholder groups involved in the construction of steel structures, including structural design and fabrication engineers and technologists, architects, steel detailers, steel inspectors and building officials.

CISC has also transitioned from classroom style delivery of short courses to live, online delivery of courses and webinars between 1 and 60 hours in length. Live online course delivery started with the first Steel Handbook course in 2010 and came to an end in October 2016 with the Seismic Design of Industrial Steel Structures. At the same time, self-paced learning was launched using the recordings of these sessions packaged with assignments, quizzes, exams and offline Q&A with the Course Leaders.

Today, all CISC courses are developed using eLearning tools and hosted and presented to students through the CISC Self-Paced Learning Centre. CISC will continue to present live 1 to 1.5-hour live webinars on hot topics for engineers, detailers, fabricators and educators in the structural steel industry in Canada.

CISC Self-Paced Learning Centre. The quality of the end-product is noticeably higher since content and delivery are polished during the development stage. With modules now divided into topics rather than blocks of time, the learner can tailor the session to the priority topics and time available. eLearning tools also allow the use of interactive educational techniques along with integration of video and examination. CISC has implemented one-on-one tutoring with the subject matter experts and is developing a knowledge base of questions and responses for the ongoing benefit of course registrants.

With the introduction of updated building and bridge design standards in 2014, and the 2015 National Building Code of Canada in early 2016, the schedule for updating existing courses has been very full. Current activities and plans are described briefly in the following paragraphs.

In late 2015, the four design examples in **Steel Bridges – Design, Fabrication and Construction** were reworked based on the 2014 CSA Canadian Highway Bridge Design Code. The updated course is now available in the CISC Self-Paced Learning Centre. The course is being translated into French and will be developed using eLearning tools by the spring of 2018.

What's New: CISC Handbook and CSA S16-14 is the first course produced using eLearning tools and available without a live delivery.

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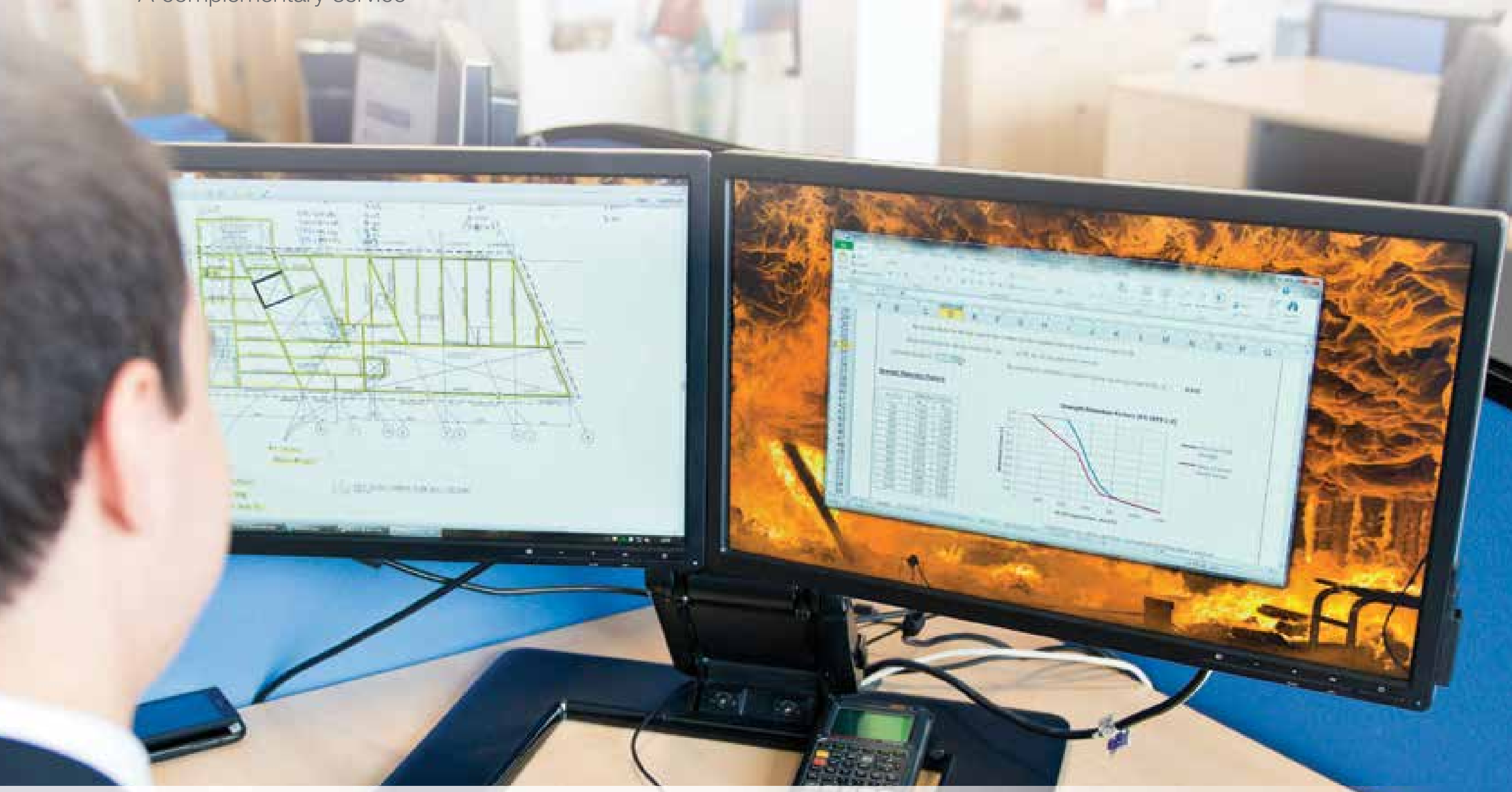

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This course covers the changes in CSA S16-14 and the design of steel members and elements connections using the recently published 11th Edition of the Handbook of Steel Construction. The course is comprised of nine modules totaling approximately six hours of material. The CISC Self-Paced Learning Centre rolled this course out in February 2017. Thirty-five students enrolled in this course during the first three months that it was available. Students continue to enroll as each province adopts the 2015 National Building Code and S16-14 comes into effect in their province.

Connections 1 is being updated and re-recorded using eLearning tools but given its length of approximately 40 hours, it will not be ready until the end of 2017. The new CSA S16-14 necessitated the update. The goal of this course is to assist steel industry personnel in their understanding of basic connection design principles, and to design simple welded and bolted connections suitable for fabrication. A French language version of this course will be developed following the English release.

Connections 2 is the second course in the three-level Connections Design Series and intended to develop the skills necessary for the design of more complex welded and bolted steel connections suitable for fabrication. It is also the basis for CISC accreditation as a conventional steel connections design engineer. A new course leader is in place and will begin the updating and recording in early 2018.

Seismic Connections for Steel Framed Buildings is the third course in the Connections Design Series and scheduled for updating in 2018. It will be the basis for CISC accreditation as a ductile steel connections designer. The objective is to assist design and fabrication engineers in their understanding of energy-absorbing and elastic connections in Seismic Force Resisting Systems.

Inspection of Steel Building Structures was a four-day classroom style course providing requirements, recommendations and resources for the inspection of steel-framed buildings. It is also the basis for CISC accreditation as a steel inspector. Now that this course needs to be updated to CSA S16-14, NBCC 2015 and numerous material and welding standards released in the past two years, it will be developed using the eLearning platform. Development work is scheduled to finish in January 2018. The French language version of this course will be updated and developed following the English release.

Single Storey Building Design was developed and last delivered live, online in the fall of 2015. Unfortunately, the 2015 NBCC was not published at that time so an incremental update and development for the eLearning platform began in October 2017. A French language version of this course will be developed following the English release.

New live webinars in the 1 to 1.5-hour length range will continue to be produced by CISC and delivered online by subject matter experts prior to being added to the CISC Self-Paced Learning Centre. An initial live delivery is in keeping with the timelines of these focused topics. One of the first will be **NBCC 2015 Low Hazard and Low Seismicity Procedures,** followed by **CISC Code of Standard Practice - Engineer's Perspective** and **Fire Safety Engineering.** AS

CISC Research Grants Update 2017-2018

By Maura Lecce, Ph.D., CISC Research Manager and Professor, Civil Engineering Technology, Seneca College of Applied Arts and Technology

The CISC is committed to supporting research programs at leading Canadian schools of engineering and engineering technology as part of its mandate to support the development of expertise, knowledge and innovation in steel design and construction. The objectives of the CISC Research Grants Program are to support the research needs of the structural steel industry as they relate to building structures and bridges, and to foster excellence in steel education and research. Since 1995, a total of 120 grants have been awarded, supporting steel research at institutions across the country.

AREAS OF RESEARCH include the behaviour of steel components and systems as they relate to maintaining safe and cost effective codes and standards, advancing the sustainability of structural steel construction, improving design methodologies, and exploring innovative structural solutions that will keep steel construction competitive. Topics for research come from codes and standards committees, stakeholders in steel construction, and from the Canadian research community. The Research Grant Program has led to the development of design guidelines, innovation in structural steel solutions, and maintaining safe and cost-effective codes and standards.

The CISC recently awarded four research grants, totalling $95,950, for the 2017-2018 academic year. The research projects that began in September 2017 are described below:

Research Title:
Simplified Design Methods for Steel Multi-Tiered Braced Frames in Regions of Low and Moderate Seismicity

Researcher:
Dr. Ali Imanpour, Assistant Professor, Department of Civil and Environmental Engineering, University of Alberta

Description of Research: Steel multi-tiered braced frames are commonly used in tall single-storey buildings such as airplane hangars, sports facilities or industrial plants to provide lateral bracing when it becomes impractical to use braces that extend the full storey height (Figure 1). Although the multi-tiered configuration offers significant advantages in high seismic areas, it is also the most common option chosen by structural designers in low and moderate seismicity regions of North America. In view of the extensive use of such frames in regions of low and moderate seismicity, improved seismic design methods are needed that address the seismic risk outside of high seismic hazard regions.

The overarching objective of this research project is to provide tools for design engineers and code developers to optimize the design of steel multi-tiered concentrically braced frames in regions of low and moderate seismicity. The project has four specific objectives: i) assess the seismic behaviour of frames in regions of low and moderate seismicity in Canada; ii) evaluate current CSA S16 seismic design provisions, with a focus on low-ductile systems, iii) develop simplified seismic design guidelines consistent with CSA S16; iv) evaluate consistency of the proposed design criteria with available prefabricated structural systems. This research will involve an extensive literature review, parametric numerical studies and experimental studies. Ultimately, design recommendations will be made based on the results of experimental testing and numerical simulations. A simplified format for recommendations will provide an appropriate tool for design engineers dealing with single-storey buildings in Canada. This will reduce the construction cost and keep steel competitive in Canadian industrial market sectors.

This project is the first phase of a larger research program to develop an innovative modular steel structure for industrial buildings with a focus on low and moderate seismic regions.

Image courtesy of A. Imanpour

FIGURE 1: Multi-Tiered Braced Frame

Research Title:
Design of Beams with Overhanging Segments Against Lateral Torsional Buckling

Researcher:
Dr. Nicolas Boissonnade, Associate Professor, Department of Civil and Water Engineering, Université Laval

Description of Research: This research is to investigate the lateral torsional buckling of beams with overhanging segments (commonly known as the Gerber girder system). Such structural elements are quite popular in Canada, and used widely for multi-bay arrangements. It has the advantages of maintaining a statically determinate system with an effective and economic balance of hogging and sagging bending moments and reduced deflections, while avoiding complex and costly moment connections. Currently there is a lack of clear, practical design solutions for the lateral torsional buckling resistance of the overhanging and simple span segments and for the connections to vertical supporting members (at locations of maximum hogging bend) which can lead to unsafe and unpractical designs. The present project therefore aims to (i) fully understand the behaviour of such systems primarily through finite element analyses (image of FE model in Figure 2), (ii) characterize the key design parameters, (iii) develop an adequate design method and (iv) provide design engineers with simple yet effective and economic design solutions and tools.

Image courtesy of N. Boissonnade

FIGURE 2: FE Model - Lateral Torsional Buckling of Beam with Overhang

Research Title:
Analysis of Concentrically Loaded Braced Frame Using Continuous End Plate

Researcher:
Dr. Nathalie Roy, Associate Professor, Department of Civil Engineering, Université de Sherbrooke

Description of Research: The purpose of this research is to examine the behaviour and design of continuous end-plate connections in concentrically braced frames. This type of connection is not explicitly addressed by the current design standards, thus resulting in designs that are often too conservative. Furthermore, although this connection is usually assumed conceptually to be pinned, the effect of the continuous end plate may qualify this type of connection as semi-rigid resulting in an actual load-resisting system behaviour different from the one originally assumed. Three connections will be examined: extended end plate with the beam fully welded all around against the end plate (EPF), extended end plate with only the beam web being welded to the end plate (EPW), and a conventional connection using independent pairs of double angles clips (DAC). Specific objectives of the experimental program are to: i) compare the moment transfer capacity of a beam-gusset assembly connected to the column with a continuous end plate vs. one connected using independent double angle clips; ii) determine the influence of an all-around weld connecting the beam to the continuous end plate; iii) quantify the energy dissipation capacity of continuous end plate connections under cyclic loading; iv) analyze the rigidity of the connections.

The results of this research will lead to a better understanding of the connection component itself, as well as its influence on the overall structure and will ultimately enable the connection engineers to optimize their design (while potentially saving on material, and welding consumables).

Dr. Roy, principal researcher, is working in collaboration with her colleagues Dr. P. Laboissière and Dr. S. Parent.

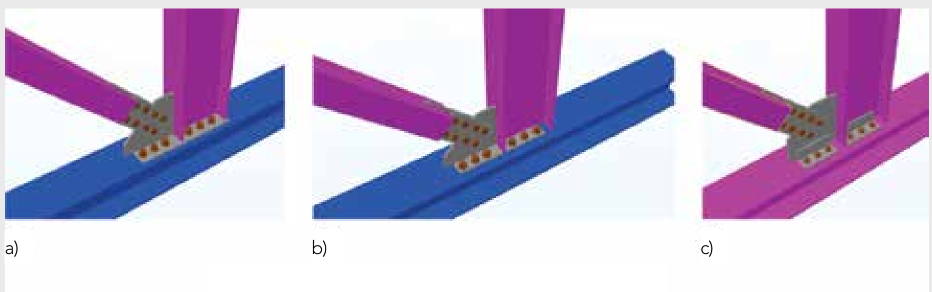

Image courtesy of N. Roy

FIGURE 3: Connection Types a) EPF b) EPW and c) DAC

Research Title:
Performance Based Seismic Design of Innovative Damage Free Rocking Steel Bridge Piers

Researcher:
Dr. Shahria Alam, Associate Professor, School of Engineering, University of British Columbia, and Dr. Robert Tremblay, Professor and Canada Research Chair in Earthquake Engineering, Department of Civil, Geological and Mining Engineering, École Polytechnique de Montréal

Description of Research: The objective of this research is to investigate, through experimental and numerical studies, the concept of self-centering mechanisms in steel bridge piers. Since any damage to a transportation system could have significant impacts on society and economy, the need for the design and development of new bridge components and systems with damage avoidance mechanisms has been increasingly highlighted over recent years. The use of steel rocking bridge piers, where energy dissipating elements (Figure 4) can be easily removed after an earthquake, can significantly reduce construction time and expenses, seismic damages and corresponding economic losses. However, currently there is no proper guideline for designing such piers. This research will examine the various damage states and performance of steel rocking bridge piers to eventually develop performance-based design guidelines for inclusion in the Canadian Highway Bridge Design Code (CSA S6).

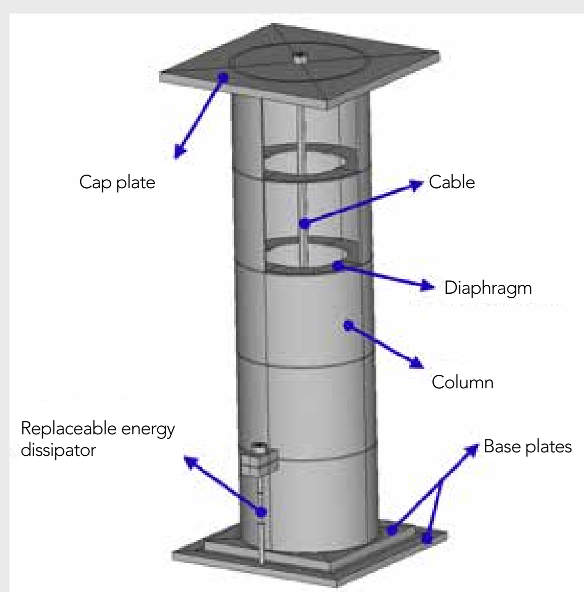

Image courtesy of S. Alam

FIGURE 4: Components of Rocking Steel Bridge Piers

2017 H.A. Krentz Research Award

Maura Lecce, Ph.D., CISC Research Manager and Professor, Civil Engineering Technology, Seneca College of Applied Arts and Technology

H.A. Krentz Research Award recipient, Dr. Ali Imanpour (centre), together with CISC Research Committee Chair, Terry Wilk (left) and CISC E&R Council Chair, Michael Holleran (right).

THE H.A. KRENTZ RESEARCH AWARD is made in appreciation of the contributions made by Hugh Krentz to the engineering profession, the development of codes and standards, the education of engineers and to the development of the Canadian steel industry. The award, made in addition to the research funds granted to the recipient through the CISC Research Grant Program, is presented annually to the researcher whose project has special merit and interest with promise that it will make a significant contribution to understanding the behaviour of steel structures, advances in the economy, safety or reliability of steel structures. A gift of $5,000 is part of this notable award.

The recipient of the 2017 H.A. Krentz Research Award is Dr. Ali Imanpour, Assistant Professor, Department of Civil and Environmental Engineering, University of Alberta, for his research on Simplified Design Methods for Steel Multi-Tiered Braced Frames in Regions of Low and Moderate Seismicity. The CISC granted Dr. Imanpour $25,000 through the Research Grant Program.

Dr. Imanpour's primary research focus involves improving seismic stability of steel structures through advanced analytical simulation and experimental testing. He has developed new seismic design guidelines for steel multi-tiered braced frames that have been recently adopted by the Canadian steel design standard (CSA S16) and the American Institute of Steel Construction (AISC 341).

Dr. Imanpour was presented the H.A. Krentz award at The Canadian Steel Conference on September 28, 2017, in Calgary, Alberta. AS

Continuing Education Courses

CISC continues to increase the number of courses and seminars available in the Self-Paced Learning Centre, which offers online education that qualifies for Continuing Education Units (CEUs) using video presentations packaged with notes, design guides, assignments, tutoring and examinations where available.

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

WHAT'S NEW: CISC HANDBOOK AND CSA S16-14

This six-hour course (nine modules) covers the changes in CSA S16-14 and the design of steel members and elements using the new 11th Edition of the Handbook of Steel Construction. Upon completion, the learner will be awarded 0.6 CEUs. The first three modules cover an overview of the 11th Edition of the Handbook and the major changes and new provisions introduced in CSA Standard S16-14, "Design of Steel Structures" and the CISC Commentary on CSA S16. Changes in Clause 27 Seismic design are included in this session. The intent of the remaining six modules is to provide understanding on the background and use of design aids contained in the new Handbook while drawing the participants' attention to changes, new additions and hidden gems. However, overall building behaviour and seismic design are outside the scope of the Handbook of Steel Construction and this portion of the course. The nine modules will cover:

1. Handbook Overview
2. Part 1 - Changes to CSA S16-14
3. Part 2 - CISC Commentary on CSA S16-14
4. Part 3 (a) - Bolt and Weld Data
5. Part 3 (b) - Framed Beam Shear Connections
6. Part 4 - Compression Members
7. Part 5 - Flexural Members
8. Part 6 - Properties and Dimensions
9. Part 7 - CISC Code of Standard Practice and Miscellaneous Data

Modules 4 through 7 present 22 design examples to illustrate design aids for bolts, welds, simple beam connections (single angle, double angle, end plate, seated and shear tab), tension members, compression members and flexural members (composite and non-composite).

The Handbook of Steel Construction contains detailed information on the design and detailing of structural steel in metric units. The new 11th Edition is intended to be used together with the National Building Code of Canada 2015. Member design tables are based on steel grades ASTM A992, A572 Grade 50, A913 Grade 65, A500 Grade C and CSA G40.21-350W.

STEEL BRIDGES – DESIGN, FABRICATION, CONSTRUCTION

This 16-hour course covers the design, fabrication and construction of steel bridges based on CAN/CSA-S6-14, Canadian Highway Bridge Design Code. The course provides understanding of design theory and the rationale behind Code provisions as well as the application of specific Code formulae and requirements. The practical and economical aspects of fabrication, erection, choice of material and their impact on design have been emphasized.

The presentations and the Course Notes include four updated design examples illustrating extensive design calculations for I-girders and box girders of straight and curved configurations. Topics include fatigue and brittle fracture, integral abutments, aesthetics, design process and economics, highway bridge loads and methods of analysis, I-girder design, straight and curved box girder design, wind and seismic effects, fabrication and economical details, construction and erection methods, and an architectural perspective on pedestrian bridges.

Major changes and new provisions that were introduced in the 11th edition of CAN/CSA-S6 and their effect on the design of steel girders are highlighted.

INDUSTRIAL BUILDING DESIGN

This eight-hour course focuses on practical and economical solutions for framing a typical industrial building to the requirements of the 2010 National Building Code of Canada and the pertinent provisions of CSA Standard S16-14. Whenever possible, relevant provisions in the NBCC 2015 are discussed. The course material will reference the new third edition of the Crane-Supporting Steel Structures: Design Guide and feature a completely reworked design example.

This course also has the following goals:

- Identify the unique environmental and mechanical loading conditions in industrial buildings
- Learn the applicability and limitations of current codes and standards in Canada, with a comparison to other jurisdictions
- Select the most cost effective framing schemes
- Tips for cost effective design
- Design crane-supporting girders, stepped columns, purlins and girts, lateral force resisting systems, roof trusses and efficient connections
- Understand serviceability considerations and limitations
- Design for high and low temperatures
- Learn the implications of seismic provisions for these structures
- Other topics include fatigue, standing seam roofs, rehabilitation, tolerances and coatings.

SEISMIC DESIGN OF INDUSTRIAL STEEL STRUCTURES + CSA S16-14 ANNEX M

This four-hour course presents the seismic design requirements of the National Building Code of Canada 2015 and Clause 27 of CSA S16-14 as these requirements apply to industrial buildings. Seismic base shear calculations are presented for an example mill-type industrial building in Vancouver, Edmonton and Montreal. The results of Equivalent Static Force Procedure and Dynamic Analysis Procedure (Response Spectrum Analysis) for the example building are presented and compared. The choice of Seismic Force Resisting Systems for industrial buildings is discussed and the requirements for each are highlighted.

Annex M of CSA S16-14 is introduced. The provisions of Annex M extend and modify the requirements of Clause 27 of CSA S16-14 as these requirements apply to industrial structures which do not resemble buildings. Seismic Force Resisting Systems, redundancy, damping, effective mass, methods of analysis and vertical earthquake effects are reviewed. AS

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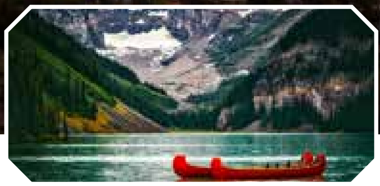
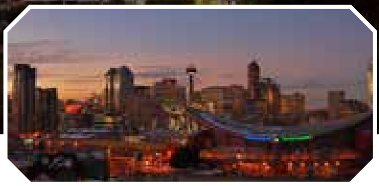

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