ADVANTAGE STEEL

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CANADIAN INSTITUTE OF STEEL CONSTRUCTION
INSTITUT CANADIEN DE LA CONSTRUCTION EN ACIER

NO. 74 WINTER EDITION 2023/2024

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ADVANTAGE STEEL
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The Gordie How International Bridge
Three Canadian companies supply vital steel to new Canada-U.S. bridge

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.

ED WHALEN, P.Eng.
President & CEO
CISC-ICCA

Silence Not

Could it be that I have run out of things to say? Those that know me know otherwise, but I have to say I have struggled to finish this article. As most now know, I am leaving the CISC this year after 15 years in the position. Time flies! So, what does one put in their potentially last article? Do I give a "15 years in review," a bit like those reviled "What my family did this past year" letters received at around Christmas time, or talk about how I will spend my time watching the 30-minute re-runs of the news all day long in my retirement? I do like news and that may happen, but I will spare you all.

I can say that the last 15 years have been a very dynamic one, to be sure, for the steel industry. We had the "great recession" where fabricators prayed for steel prices to go up, offshoring and modularization in the industrial sector, prompt payment legislation fights with GCs, anti-dumping trade cases as the defendant and plaintiff, insane governments and policies, 232 tariffs, COVID-19, lack of professional and skilled trades, incomplete drawings, new technology and automation. The seismic experts feel that all of Canada is going to shake itself to death and change the building code accordingly, and now it isn't the best or most efficient design that matters, it is the lowest embodied carbon that counts. Resilient design for climate change is all the rage, where resiliency for seismic disasters (psst, that's you, B.C.) remains brushed under the carpet despite the potential carbon effects of a total city rebuild. It's not if – it's when. Governments preach lowering embodied carbon in construction and then, as of December 2023, announced they will provide financial incentives to burn wood by-products because, as they claim, it is a net-zero carbon loop. If you torture your data long and hard enough, you can get it to say just about anything, I always say.

So, insanity is reining, social media is peddling anything you want to believe, politicians revile in conduct we would have found downright disgusting and intolerable years ago, democratic countries appear to be at the brink and more and more countries appear willing to go to war.

They always say, "Where there are challenges, there are opportunities." The steel industry came through COVID, for example, better than anyone could have imagined, prompt payment legislation is almost universal across the country, steel has a terrific story with embodied carbon, and it appears that North America is more aligned in policy than in recent past (until next fall, possibly).

On the carbon front, we have discovered that "wise procurement" will have a great impact on steel construction in the future. By sourcing from specific North American mills (Gerdau and ArcelorMittal Dofasco, for example), embodied carbon for steel products come in at less than half the industry averages. This information/data alone, when used with great steel design, blows away most all other systems. We have seen a recent case of this in B.C., where an owner pulled an all-wood design and went with a steel solution providing net zero and saving millions over the initial mass timber proposal (more on that in the months ahead). So, to those who think the battle is over, it is just firing up… Speaking of fire, you all know

"The seismic experts feel that all of Canada is going to shake itself to death and change the building code accordingly, and now it isn't the best or most efficient design that matters, it is the lowest embodied carbon that counts."

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that burning wood creates carbon emissions, right? Some would hope we turn our heads and stick to our social media feeds, where all the true facts come from.

I leave at a very interesting time. Apart from embodied carbon and all the other chaos, AI seems to be a new, exciting and possibly scary addition to the list. What this will mean for the steel sector, engineers, architects and automation remains to be seen. There are many opportunities staring us in the face should we have the capacity to see them. Many companies will thrive and disrupt, making our fast world even faster.

Now, I am not leaving tomorrow, but it will be this year, so I will take this time to thank all the supporters of the CISC over the years. It's your leadership, support and horsepower that keeps this industry strong, competitive and vibrant. To those who elected not to support the CISC for whatever reason, this may be the time to become part of the solution.

So, if you'll excuse me, it's time for the news. AS

LOGAN CALLELE, P.Eng.
Manager, Engineering
CISC-ICCA

CISC Engineers' Corner

CISC provides this column as part of its commitment to the education of those interested in the use of steel in construction. Neither the CISC nor the author assumes responsibility for errors or oversights resulting from the use of the information contained herein. Suggested solutions may not necessarily apply to a particular structure or application and are not intended to replace the expertise of a licensed professional engineer or architect. For questions or comments on this article or any of the technical information provided by CISC, please contact engineering@cisc-icca.ca.

A "New Look"

CISC has a history of providing answers to your technical questions about structural steel. Over the past 40-plus years, we've published answers in this magazine, as well as thousands of answers via correspondence with individuals in the steel industry. We will be continuing that tradition in the Engineers' Corner of *Advantage Steel* but with a new look – instead of providing a question-and-answer format, we'll aim to provide miniature design guides on select topics.

"I'd Rather Design a Concrete Beam..."

During a recent meeting of the CISC Building and Structures Committee, one consulting engineer related that he'd "rather design a concrete beam than have to do all of the design checks associated with a steel-to-concrete connection." As you might imagine, our engineering team took notice of this, and as most of our current team members have consulting experience, we empathized with the complexity of designing this simple connection (pun intended). Thus, to start our new design guide miniatures, we will be looking at steel-to-concrete connections. Now when you think about it, this is actually quite a broad topic that includes column base plate anchorage – both cast-in-place and post-installed – as well as beam to embedded plate connections, and in both cases, with and without bracing. We anticipate addressing all of these topics in the next three editions of *Advantage Steel*, and in particular take a deep dive into the coming changes to anchor rod design in Canadian standard S16 (2024). But for now, we'll tackle the common case of steel to embedded plate connections.

Our First Miniature: Steel Beam to Embedded Plate Connections

Common steel beam to embedded plate connections are shown in **Figures 1 and 2**, and as can be seen,

FIGURE 1: Simple beam connection (steel beam to embedded plate) – slotted angle.

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.

FIGURE 2: Large axial loaded embedded plate to beam connection.

"The governing design requirements in Canada for the embedded steel plate anchorage and associated concrete failure modes are found in CSA A23.3 (2019) Annex D."

regardless of the style, there are two distinct parts to the design – the concrete side and the steel side. While the design of the steel side is relatively straightforward for simple beam end connections, with the design guidance and tables found in the CISC Handbook of Steel Construction being mostly applicable, the design of the anchorage on the concrete side is much more complex.

The governing design requirements in Canada for the embedded steel plate anchorage and associated concrete failure modes are found in CSA A23.3 (2019) Annex D. For the design of the simple connection shown in **Figures 1 and 2**, for example, the following limit states need to be assessed (refer to clause D.6 and D.7 of CSA A23.3 for tension and shear design requirements, respectively):

i. Resistance of the steel anchor (stud) in tension.
ii. Resistance of the steel anchor (stud) in shear.
iii. Unreinforced concrete breakout in tension.
iv. Unreinforced concrete breakout in shear.
v. Concrete sideface blowout (anchor in tension).
vi. Anchor pull out resistance (anchor in tension).
vii. Concrete pry-out (anchor in shear).
viii. Anchorage (stud) combined shear and tension failure.
ix. Concrete reinforcement, if required to anchor the concrete breakout in shear.
x. Steel embedment plate flexure.
xi. Interaction of the anchor (stud) group under both shear and tension load.
xii. The steel connection to the beam limit states – varies depending on the connection used.

Thus, to design a "simple" embedded steel connection is quite complex, unless the designer is very familiar with Annex D; for instance, in order to assess these limit states, there are over 20 equations to evaluate with over 50 separate variables. Engineers have come up with software

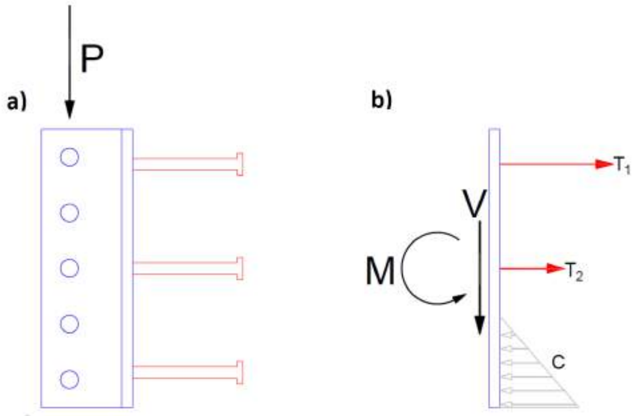
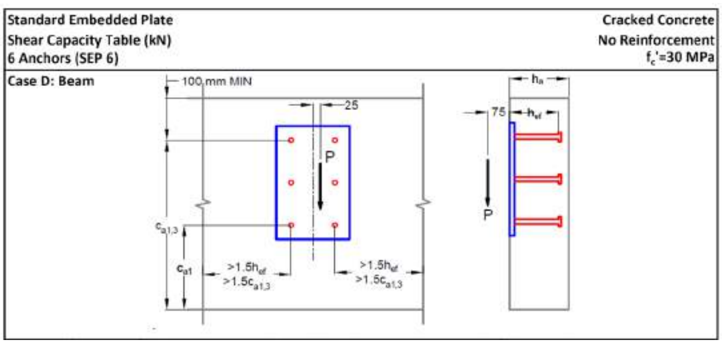


FIGURE 3: Strong axis beam end rotational restraint assumed (conservative) effect on anchorage forces.



c_{a1} (mm)	h_{ef} (mm)	h_a (mm)				
		200	300	400	500	600
50	100	49.1	58.6	66.2	72.5	73.9
	150	52.3	62.7	71.1	78.1	79.7
	200	52.6	63.2	71.8	79.0	80.7
100	100	54.8	65.1	73.1	79.8	85.4
	150	58.8	70.4	79.6	87.3	93.9
	200	59.4	71.4	81.0	89.1	96.2
150	100	60.2	71.2	79.7	86.6	92.4
	150	64.9	77.3	87.2	95.3	102.3
	200	66.2	79.6	90.3	99.3	107.1

FIGURE 4: Excerpt from University of Alberta report (see references) showing some of the edge effects when the recommended design rules of thumb are not applicable.

solutions, spreadsheet solutions and tabulated solutions to this complex problem. One notable project to develop proposed standardized embedment connections along with tabular capacities is the University of Alberta Steel Centre's project "Standardization and Testing of Embedded Plates for Design, Fabrication and Construction Economy," which can be found at www.steelcentre.ca/reports, and henceforth is referred to as "the report." There is ongoing work at the University of Alberta by Dr. Doug Tomlinson on embedded steel plate to concrete connections, and we can look further to future developments on this topic.

This research report provides a summary of the current CSA A23.3 (2019) Annex D requirements for these embedded plate connections, some of the limitations of Annex D, and a description of the results of their testing program for these connections. A few key findings described in the report are:

- **i.** Not surprisingly, the edge distance between the anchor and the closest free edge of the concrete plays a critical role in both the theoretical and tested response of these connections.
- **ii.** Adding reinforcing steel (stirrups) to transfer the load between the shear studs and the concrete can help increase the connection capacity, but care must be taken in the reinforcing steel detailing.
- **iii.** Both in-plane and out-of-plane eccentricities affect the capacities of these connections. In particular, the effect of beam end rotational restraint transferring an out-of-plane moment to the connection needs to be accounted for in the design. **Figure 3** shows the assumed load path to transfer the beam end rotation restraining moment to the anchors. This beam end restraint corresponds to an out-of-plane moment on the plate/anchors and is assumed herein to be equal to 75 mm multiplied by the beam shear force. In-plane eccentric effects, potentially caused by placement tolerances between the embedded plate location and the steel beam centerline location, are also discussed in detail in the report. In both cases, the effect of the eccentricity is evaluated assuming elastic distribution of loads and rigid plate rotation, a conservative design assumption.

The report concludes with a set of design tables that the CISC believes will be very useful to the everyday practicing structural engineer. The design tables provide recommendations for both a beam tension and shear load for a variety of standardized plate geometries and stud embedment lengths (h_{ef}); see **Figure 4** for an excerpt of these tables. The design values account for both eccentricity and edge distance effects as described above, which should be useful to both the Engineer of Record (EoR) designing the anchorage on the "concrete side" and the connection design engineer designing the steel connection.

A review of the design tables in the report shows that the design recommendations can be consolidated into recommendations for shear stud loadings based on an in-field condition, which has the nearest shear stud at least 1.5x h_{ef} away from the closest free edge of the concrete, and a variety of edge configurations. Though, as mentioned previously that the strength of the anchors is significantly affected by how close they are to a concrete free edge, it is a common design scenario to design an in-field embedded plate. These consolidated recommendations are proposed herein as a rule of thumb and are valid for the embedded plate connection shown in **Figure 5**. Further, these recommendations have been independently verified with two separate industry standard anchor design software programs.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"In-field" Embedded Plate Design Rules of Thumb

Design for Applied Shear: (Max Shear capacity = No. of Anchors (N) x v_{r_sa})

Stud Embedment Length (h_{ef})	v_{r_sa}
100 mm	20 kN/anchor
150 mm	30 kN/anchor
200 mm	35 kN/anchor

NOTE: These design rules of thumb are for the connection shown in Figure 5 only.

Design for Applied Tension: (Max Tensile capacity = No. of Anchors (N) x t_{r_sa})

Stud Embedment Length (h_{ef})	t_{r_sa}
100 mm	15 kN/anchor
150 mm	20 kN/anchor
200 mm	25 kN/anchor

NOTE: These design rules of thumb are for the connection shown in Figure 5 only.

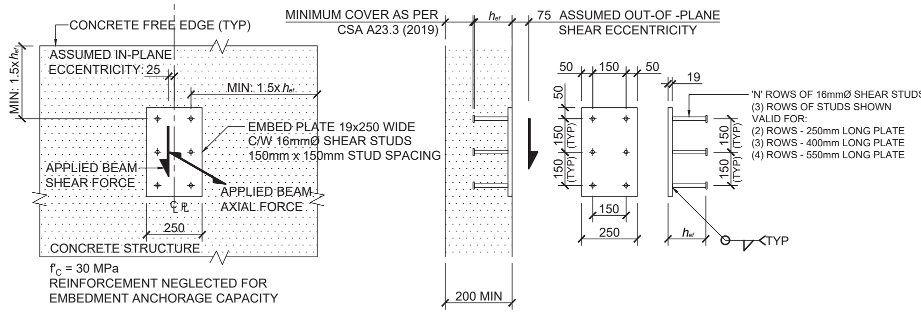

FIGURE 5: Recommended standardized embedded plate compatible with the recommended design "rules of thumb."

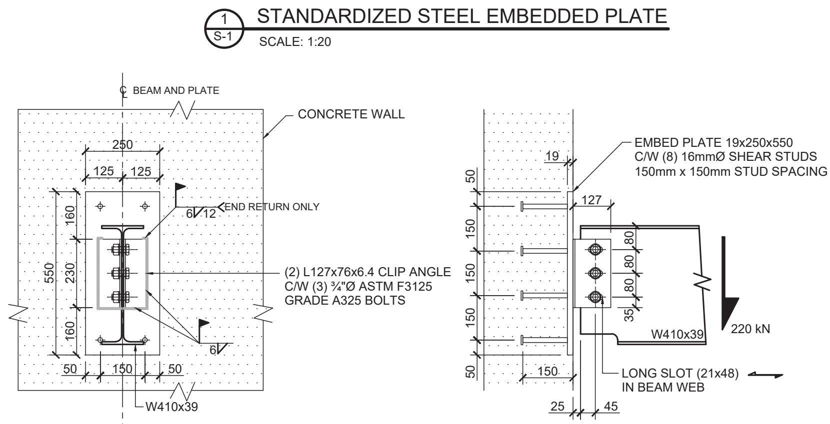

FIGURE 6: Embedded plate sample calculation sketch.

Some limitations on the above recommendations should be noted:

- If the embedded plate edge distances are smaller than what is shown in **Figure 5**, then these values may be substantially reduced and readers are directed to a more thorough discussion of this topic given in the report.
- These rules of thumb are valid for the two, three, and four rows of anchors for the connection shown in **Figure 5**.
- The concrete is normal density, cracked and unreinforced.
- The tensile strength of the anchors is 420 MPa (minimum) formed from steel considered ductile, as defined by CSA A23.3 (2019), and a weld that fully develops the anchor's strength between anchor and plate. Note that CSA W59 (2018) Type B studs (Fu=450 MPa) – see Table H.1 in W59 – are the more deformed studs used in the industry.
- The governing limit states corresponding to the above recommendations vary. Thus, if the design requires that the critical limit state be identified, then the designer is advised to perform the calculations given in Annex D of CSA A23.3 (2019).

Sample Connection Calculation

To illustrate the potential applicability of these design recommendations, let's consider a design example. A W410x39 (350W) steel beam is connected to a concrete structure with an embedded plate connection, similar to **Figure 5**, and is loaded such that the factored end shear reaction on the beam is 220 kN. Determine an appropriate embedded plate connection using the rules of thumb noted above.

No. of shear anchors required: – h_{ef} = 100 mm — N = 220 kN / (20 kN/anchor) = 11 anchors – greater than 8 anchors, so investigate a deeper embedment length.

– h_{ef} = 150 mm — N = 220 kN / (30 kN/anchor) = 7.3 anchors – so (8) 16 mm *∅ anchors with 150 mm* embedment.

Using Tables 3-37 and 3-38 in the CISC Handbook of Steel Construction (12th Edition) a double clip angle connection L102x76x7.9 (300W) angle with (3) ¾" *∅ ASTM F3125 Grade A325 bolt* – use a minimum of (3) rows of bolts for lateral torsional buckling stability of the end of the W410 beam. See **Figure 6** for the final connection design – note that L127x76x7.9 angles are used instead to allow sufficient room for the slotted connection.

Lastly, it is worthwhile noting the difference between the steel connection used in this example and that shown in **Figure 2**. In particular, the double-angle connection presented in **Figure 6** has less rotational stiffness than the shear-plate connection shown in **Figure 2**; however, that does not make one inherently better than the other. For instance, the clip angle connection would be better suited for beams primarily loaded in shear because of its rotational flexibility. Indeed, the bolt gauge at the extreme position of the slot is slightly larger than the 75-mm limit shown in **Figure 5**, but because of its rotational flexibility, the connection is deemed adequate. Conversely, the shear-plate connection would be more appropriate to transfer predominantly axial loads from the beam as the welds from the clip angle may unzip and the web slots do not allow the bolts to go into bearing to resist the axial loads.

Constructability

Several constructability considerations need to be evaluated when designing both the steel side and the concrete side of the embedded plate connection. Some of those considerations are:

- Embedded plate placement tolerances – the industry standard is to expect ± 12 mm for the face of the concrete form and ± *25 mm for the position of the embed in the plane of the wall.* The 25-mm eccentricity shown in **Figure 5** allows the EoR to accommodate the normal tolerances that can be expected during construction without needing to reevaluate the connection.
- Consistent geometry and anchor spacing – the selection of standardized plate size and anchor spacing allows greater efficiency in fabrication and less chance for errors to propagate during field installation. That said, there will always be unique design situations that require customized plate geometry or layout.
- Tie off shackle hole or nailing holes – adding a hole at the top of the gusset to allow attachment of a shackle (see **Figure 2**) for safety during placement of large embedded plates. For smaller plates like that depicted in **Figure 5,** it is more common to fabricate a nailing hole to help secure the embed plate to the form and/or surrounding reinforcement.
- Slotted holes with plate washers – when accommodating the plate placement tolerances, it is common to use a bolted steel connection that includes a long slot orientated perpendicular to the plane of the concrete face. When slotted holes are used it is common practice to use a plate washer, however, the configuration shown in **Figure 6** can be considered to avoid the extra plate washer.

Forming the Steel and Concrete Together

In Canada, the design of a steel beam to embedded plate connection is often split between the EoR, who designs the anchorage and embedded plate, and the fabricator's connection design engineer, who designs the beam connection welded to the embedded plate. The information in this article should be of benefit to both of these engineers as well as other sectors of the steel industry. The simple rules of thumb will allow design engineers to quickly determine the size of moderately loaded steel-to-concrete connections, especially when combined with the connection information given in the CISC handbook. It will also allow fabricator and connection design engineers to detail the steel side of the connection to suit both constructability considerations and the design intent (axial load or shear load dominant). However, this article hasn't covered all aspects of steel-to-concrete connections – in future articles, we'll continue to explore the steel-to-concrete connection topic by reviewing:

1. Basic column base plate and anchorage connections,
2. Heavily loaded steel beam to concrete connections – including bracing, and
3. Bracing connections at column base plates.

Let us know if you enjoyed this article and if you would like to see more of this kind of content by sending comments and suggestions for future topics to ***engineering@cisc-icca.ca.*** AS

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2023 CISC ALFRED F. WONG LIFETIME ACHIEVEMENT AWARD RECIPIENTS

Thank you to this year's honourees for your lifetime of dedication to the advancement of steel construction in Canada, and to the CISC through your unparalleled devotion to expanding the knowledge of the steel industry for the benefit of society, the steel construction industry and associated professions.

The recipients were honoured with the most prestigious steel award in Canada at the 2023 Canadian Steel Conference, held in Toronto on September 27, 2023.

JIM MCLAGAN

Jim McLagan spent his working life with two companies before retiring as Senior Vice President with the Supreme Group in 2013.

After graduating in Civil Engineering from Napier University, Edinburgh, Scotland (named for John Napier, inventor of logarithms), he worked in various departments of Redpath Dorman Long in England, gaining the experience required to become a professional engineer.

In 1982, he was recruited as a project manager by Canron Western Bridge and moved to Vancouver, B.C. During the next 31 years, he worked in the company's upstate New York and Portland, Oregon operations as a contracts manager before returning to Vancouver in 1999 as vice president and general manager, responsible for western operations.

In 2004, he was instrumental in arranging a merger with Supreme Steel and continued as vice president and general manager, responsible for the Canron operation until retiring.

His interest in structural steel developed during the time he worked at Redpath Dorman Long, a company that arguably was the world leader in bridge design and construction at the time. He spent the final few years with them working in the bridge and special structures department, and this resulted in a desire to be involved with complex and difficult projects.

Jim was elected to the CISC Board of Directors in 2001. In 2012, he was elected Chairman of the Board. In 2015, Jim stepped down from the CISC Board after 15 years of continuous service.

Locally, Jim was a leader and staunch supporter of the CISC BC Region, not only donating his time, but also his company's and many of his staff's time. He took the time and leadership to advance the steel industry, participating monthly in the B.C. Construction Round Table, a forum he used to share the benefits of steel with owners, engineers and general contractors.

GILBERT GRONDIN, PHD, P.ENG
MSC FROM THE UNIVERSITY OF NEW BRUNSWICK 1983
PHD FROM THE UNIVERSITY OF ALBERTA IN 1991

Following his PhD, Gilbert joined the firm Buckland & Taylor in Vancouver, where he worked as a bridge engineer for three years. He spent one year as a visiting researcher at the National Research Council of Canada, working on the development of the CSA S478 – Durability of Buildings.

Gilbert has taught and conducted research for 20 years at Université de Moncton, Memorial University of Newfoundland and the University of Alberta, where he spent 17 years. His areas of research include: Fatigue of steel structures, behaviour of steel connections and stability of steel structures.

He is currently at AECOM Canada Ltd., Edmonton office, for over 11 years, where he is a senior bridge engineer and steel specialist. His main role is to provide technical support to offices across North America. He was the technical lead for the recent development of the Alberta Bridge Fabrication Inspection Manual and keeps himself busy with the evaluation and rehabilitation of several old steel bridges across Canada.

Gilbert served on CSA Committees for 35 years, the Research Council for Structural Connections for four years, the Structural Stability Research Council for five years and AREMA for two years. He started with CSA S478 – Durability of Buildings and is a current member of CSA S16 – Design of Steel Structures.

CSA S6 – Canadian Highway Bridge Design Code (was chair of section 10 – Steel Structures for two code cycles)

CSA G40.20-G40.21 – General requirements for rolled or welded structural quality steel/structural quality steel.

MICHAEL I. GILMOR, B.A.SC., M.ENG., P.ENG., FCSCE

Mike Gilmor graduated from the University of Toronto in 1966 and was subsequently employed by the Toronto consulting structural engineering firm of Robert Halsall and Associates. In 1969 he obtained a master's degree in structural engineering from the University of Toronto and later was a lecturer in the Department of Civil Engineering.

In 1970, he joined the Canadian Institute of Steel Construction (CISC) and held various positions within the institute until June 30, 2009. He became president of CISC in April of 2002 and served as president until March 25, 2009. He was the editor of the CISC's, Handbook of Steel Construction and was co-author of the Canadian textbook, *Limit States Design in Structural Steel*.

In 2010, Mike joined Cast Connex Corporation as VP Marketing and Sales, where he served until 2013.

He is a past member of the Board of Directors of the Canadian Welding Bureau Group, was Vice-Chair of CSA S16 and was a member of CSA S473, Steel Offshore Structures, CSA W59, CSA S6 and the CSA Strategic Steering Committee on Structures (Design). Currently, he is still a member of CSA's Technical Committee, CSA S16.

Mike Gilmor was a member of the Standing Committee on Structural Design, Part 4 of the National Building Code of Canada during the 1980s, and for six years was the chairman of the Research Council on Structural Connections and was a member of their Specification Committee.

Internationally, he represented and led the Canadian delegation in ISO TC 167 and ISO/TC17/SC3 Steel.

In 1992, Mr. Gilmor was elected a Fellow of the Canadian Society for Civil Engineers for his excellence in engineering and for services rendered to his profession and to Canada. In 2001, he was the recipient of CSA's Award of Merit. In April 2023, he received recognition from CSA for his 45 years of service on technical committees of CSA standards.

CISC BC REGION AWARDS OF EXCELLENCE IN STEEL CONSTRUCTION

On May 18, 2023, the CISC team gathered with the BC Region to celebrate outstanding excellence in steel. These projects brought forth innovation, beauty, uniqueness, originality and complexity. The evening featured appearances by several high-profile Canadian politicians: Hon. Harry Bains, Teresa Wat, the Hon. Dan Coulter, Katrina Chen and Mike Hurley, as well as our keynote speaker, former Calgary Mayor Naheed K. Nenshi. These awards act as an overall celebration of excellence and a chance to gather the best and brightest of the steel construction industry. Congratulations to all of our award winners, and thank you to everyone who contributed to this celebration in steel.

COLD-FORMED STEEL AWARD

Highlighting projects where the selection of cold-formed steel was chosen to solve engineering, architectural or constructability challenges.

HighPointe Park Condominium

Maple Ridge, BC

Engineering Firm: R.D. Engineering Ltd.
Architect: Wayne Bissky Architecture & Urban Design Inc.
Owner: Concordia Group
General Contractor: Concordia Group
Steel Fabricator: Imperial Building Products Ltd.
Steel Detailer: Imperial Building Products

INNOVATION & SUSTAINABILITY AWARD

Highlighting and rewarding a company that has provided exceptional leadership in advancing the steel construction industry through innovative design or innovative new products, investments in technology, the improvement of sustainability of steel structures or safety. This award was presented by Hon. Harry Bains, B.C. Minister of Labour.

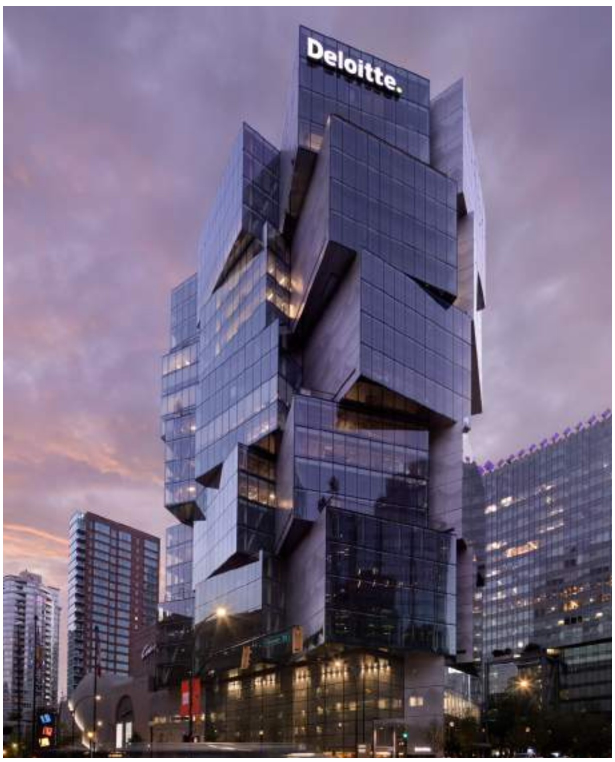
2+U

Seattle, WA

Engineering Firm: Magnusson Klementic Associates, Inc.
Architect: Pickard Chilton Architects, Inc.
Owner: Skanska Commercial Development, Inc.
General Contractor: Skanska USA Building
Steel Fabricator: AI Industries
Steel Detailer: Tru-Line Drafting Services Inc.

ARCHITECTURAL AWARD

Highlighting the architectural design of steel buildings and structures in which architectural considerations, ingenuity, creativity and innovation predominantly influenced the design of the structure. This award was presented by Teresa Wat, MLA for Richmind North Centre and Shadow Minister for Multiculturalism, Anti-racism Initiatives, Arts and Culture.



Photography by Ema Peter.

Deloitte Summit Tower

Vancouver, BC

Engineering Firm: Glotman Simpson Structural Engineers
Architect: Merrick Architecture
Owner: Westbank
General Contractor: EllisDon Constructors
Steel Fabricator: Canam Group Inc. (Previously Supermetal Structures Inc.)
Steel Detailer: Canam Group Inc. (Previously Supermetal Structures Inc.)
Steel Erector: Canam Group Inc. (Previously Supermetal Structures Inc.)

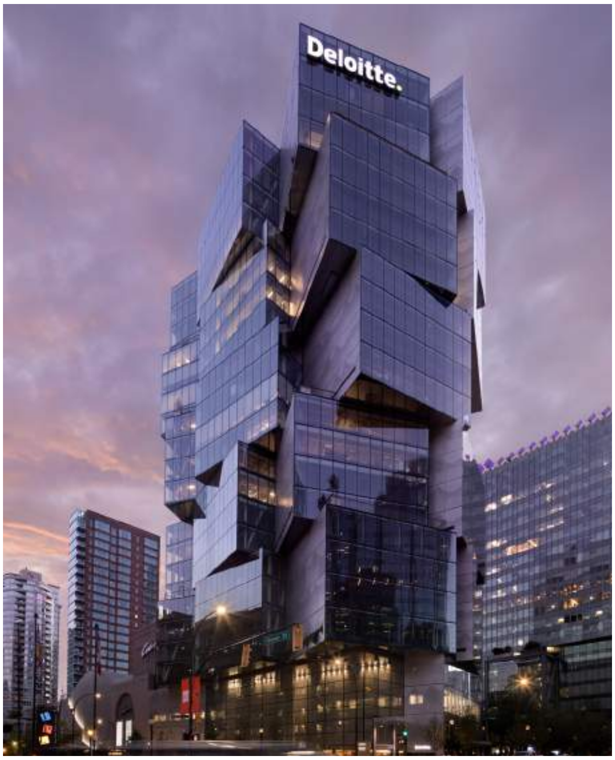
sθəqəlxenəm ts'exwts'áxwi7 RAINBOW PARK

Vancouver, BC

Engineering Firm: DIALOG
Architect: DIALOG
Owner: Vancouver Board of Parks & Recreation
General Contractor: Smith Bros. & Wilson (BC) Ltd.
Steel Fabricator: Solid Rock Steel Fabricating Co. Ltd.
Steel Detailer: Solid Rock Steel Fabricating Co. Ltd.
Steel Erector: Solid Rock Steel Fabricating Co. Ltd.

ENGINEERING AWARD

Highlighting the engineering design of steel buildings and structures in which engineering considerations, ingenuity, creativity and innovation predominantly influenced the design and construction of the structure. This award was presented by Hon. Dan Coulter, B.C. Minister of State Infractructure and Transit.



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2023 CISC BC LIFETIME ACHIEVEMENT AWARD WINNER

The CISC Lifetime Achievement Award honours outstanding individuals responsible for significant contributions to the development and success of the Canadian steel construction industry and the CISC over a sustained period of time. The award recognizes individuals from within the structural steel design, fabrication, construction and academic communities. All nominees and award winners are either current or retired members or associates with the CISC.

David Lyman
Ph.D. Tubeology

An icon within the B.C. steel industry, David Lyman's prestigious resume features over 47 years of experience. Through dedicated, hard work, David worked his way to the top of the construction industry, eventually establishing Reliable Tube by joining forces with a diverse group of steel construction colleagues and leaders. David was also an avid golfer and strong voice for women in the steel construction industry, organizing countless CISC golf events and founding The Women of Steel, an annual celebration recognizing the contributions and excellence of women within the industry.

David's unmatched work ethic, innovative spirit and dedication to the steel industry will be forever recognized, and his contributions to the growth and development of steel construction are great in both size and impact.

Congratulations on a tremendous career and enjoy retirement!

Canada's Elite Steel Fabricators 2023

Ranking	Legal Name	Total Number of plants	Maximum Capacity Output (tons/year) - all plants	CISC Steel Structures Certified	CISC Steel Bridges Certified
1	Canam Group Inc. / Groupe Canam inc.	9	327,500	✓	✓
2	Walters Inc.	3	60,000	✓	✓
3	Supreme Steel LP	3	23,000	✓	✓
4	Vulcraft Canada Inc.	2	16,000		
5	Ocean Steel & Construction Ltd.	2	15,000	✓	✓
6	Norgate Métal 2012 inc.	1	12,000		
7	Cherubini Metal Works Limited	2	10,000	✓	✓
8	Constructions PROCO inc.	2	10,000	✓	
9	MQM Quality Manufacturing Ltd.	2	10,000	✓	✓
10	RIMK Industries Inc.	1	10,000		
11	Telco Steel Works Ltd.	1	10,000	✓	
12	Burnco Mfg. Inc.	1	9,000	✓	✓
13	Algonquin Bridge Limited	1	8,500		✓
14	MSE Inc.	1	8,000	✓	
15	WF Steel & Crane Ltd.	2	8,000	✓	✓
16	AI Industries	1	7,500	✓	
17	M&G Steel Ltd.	1	7,500	✓	
18	Rapid-Span Structures / Bridges	2	7,500		✓
19	Benson Steel Limited	1	7,000	✓	
20	Structure SBL	1	7,000		
21	ACL Steel Ltd.	1	6,400	✓	
22	Lainco inc.	1	6,000	✓	
23	Marid Industries Limited	1	6,000	✓	
24	Quirion Métal inc.	1	6,000	✓	
25	Structures XL	1	6,000	✓	
26	Tresman Steel Industries Ltd.	1	6,000	✓	
27	Métal Perreault inc.	1	5,500		
28	Pittsburgh Steel Group	1	5,200		
29	Hans Steel Canada	1	5,000		
30	Lambton Metal Service	1	5,000		
31	RKO Steel Limited	1	5,000	✓	✓

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CANADIAN INSTITUTE OF STEEL CONSTRUCTION
INSTITUT CANADIEN DE LA CONSTRUCTION EN ACIER

Canada's Elite Steel Fabricators 2023

Ranking	Legal Name	Total Number of plants	Maximum Capacity Output (tons/year) - all plants	CISC Steel Structures Certified	CISC Steel Bridges Certified
32	Victoria Steel Corporation	1	5,000	✓	
33	Charpentes d'acier Sofab inc.	1	4,800	✓	
34	Abesco Ltd.	1	4,500		
35	Niik Steel Inc.	1	4,500		
36	ISM Industrial Steel Manufacturing Inc.	1	4,500		
37	Acier Sélect inc.	1	4,000		
38	Modular Fabrication Inc.	1	4,000	✓	✓
39	Sperling Industries Ltd.	1	4,000		
40	TSE Steel Ltd.	1	4,000		
41	Carry Steel	1	3,800		
42	Métal Moro inc.	1	3,500		
43	Acier Métaux Spec. inc.	1	3,200		
44	Central Welding & Iron Works	1	3,200	✓	✓
45	Acier MYK inc.	2	3,120		
46	Les Structures GB ltée	1	3,000	✓	
47	Metal-Fab Industries Ltd.	1	3,000		
48	Sturo Métal inc.	1	3,000	✓	
49	Tecno-Métal inc.	1	3,000		
50	Wesbridge Steelworks Limited	1	2,700	✓	
51	Weldfab Ltd.	1	2,520	✓	
52	Elance Steel Fabricating Co. Ltd.	1	2,500		
53	Les Industries V.M. inc.	1	2,500		
54	Steelcon Fabrication Inc.	1	2,500		
55	United Steel	1	2,500		
56	Impact Ironworks Ltd.	1	2,400		
57	Linesteel (1973) Limited	1	2,200	✓	
58	Kubes Steel Inc.	1	2,100		
59	C_ore Metal Inc.	1	2,000		
60	G & P Welding and Iron Works	1	2,000	✓	✓
61	Gensteel - Division of Austin Steel Group Inc.	1	2,000		
62	Les Aciers Fax inc.	1	2,000		

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Canada's Elite Steel Fabricators 2023

Ranking	Legal Name	Total Number of plants	Maximum Capacity Output (tons/year) - all plants	CISC Steel Structures Certified	CISC Steel Bridges Certified
63	Les Structures CDL inc.	1	2,000		
64	Mirage Steel Limited	1	2,000	✓	
65	Tek Steel Ltd.	1	2,000	✓	
66	M.I.G. Structural Steel	1	1,875		
67	Arkbro Structures	1	1,800		
68	Trevco Steel Ltd.	1	1,600		
69	Garneau Manufacturing Inc.	1	1,560		
70	Livingston Steel Inc.	1	1,560		
71	JCT Metals Inc.	1	1,500		
72	Les Réparations Marc Marine inc.	1	1,500		
73	Warnaar Steel Tech Ltd.	1	1,500		
74	Maple Industries Inc.	1	1,400		
75	Solid Rock Steel Fabricating Co. Ltd.	1	1,300	✓	
76	IBL Structural Steel Limited	1	1,200		
77	Magnum Fabricators Ltd.	1	1,200		✓
78	Norfab Mfg (1993) Inc.	1	1,200	✓	✓
79	Akal Steel (2005) Inc.	1	1,000		
80	Design Built Mechanical Inc.	1	1,000	✓	✓
81	EZ-Steel (A division of Quirion Metal)	1	1,000		
82	Mariani Metal Fabricators Limited	1	1,000		
83	Northern Steel Ltd.	1	1,000		✓
84	George Third & Son	1	950		
85	Lorvin Steel Ltd.	1	900	✓	
86	Outrider Steelworks Ltd.	1	900		
87	JP Metal Masters 2000 Inc.	1	800		
88	Summa Métal Architectural et Structural inc.	1	800		
89	MacGregors Industrial Group	1	750		
90	Trade-Tech Industries Inc.	1	700		
91	Bourque Industrial Ltd.	1	600		
92	ARDY Rigging Ltd.	1	300		✓
93	Times Iron Works Inc.	1	100		

Photo credit: Windsor-Detroit Bridge Authority

THE GORDIE HOWE INTERNATIONAL BRIDGE

Three Canadian companies supply vital steel to new Canada-U.S. bridge

BY :: WARREN HEELEY

When the new Gordie Howe International Bridge project is completed, the link for the most important trade route between Canada and the U.S. will be seriously upgraded.

Seen as a "once-in-a-generation undertaking," three Canadian steel companies and members of the Canadian Institute of Steel Construction (CISC) were chosen to supply steel in three areas of the project: CANAM (the main bridge span), Burnco Manufacturing (Canadian bridge approaches) and Cherubini Bridges and Structures (U.S. bridge approaches).

The Gordie Howe International Bridge project will address the regional transportation needs of redundancy, capacity, system connectivity and improved border processing that will positively impact the flow of traffic and goods through this key gateway. The Windsor-Detroit gateway handles "more than 25 per cent of all merchandise traded between the two countries by value."

Named in honour of legendary hockey great Gordie Howe, the project is a public-private partnership (P3) delivered by the Windsor-Detroit Bridge Authority (WDBA), a non-profit Canadian Crown corporation, and Bridging North America (BNA). WDBA is responsible for project delivery and oversight and the operation of the new crossing. BNA is responsible to design, build, finance, operate and maintain the Canadian and U.S. Ports of Entry (POEs) and the bridge, and to design, build and finance the Michigan Interchange.

The Gordie Howe International Bridge features a "cable-stayed design," six lanes with three in each direction plus a multi-use path. Its total length is 2.5 kilometres, with a clear span of 853 metres. The project also includes a "footprint for the U.S. and Canadian POEs that allows for expansion of border processing facilities" in the future.

Photo credit: Windsor-Detroit Bridge Authority.

By the numbers, the total project value is $6.4 billion, the operational period is 30 years and the number of construction workers is approximately 2,500. An interesting fact from WDBA "The bridge towers shape will reflect the curvature of a hockey stick in a slap shot."

The Bridge Steel

The cable-stayed design of the new bridge features steel as a vital component of the construction project. *Advantage Steel* spoke with the three involved steel companies for their thoughts on supplying steel to this historic project.

Burnco Manufacturing Inc.

Burnco has been in business for more than 30 years and specializes in steel fabrication at their 180,000-sq.-ft. factory in Vaughan, Ont. "We have been supplying the bridge building sector for more than 15 years," says John Boote, general manager at Burnco. "Our work for the bridge sector is becoming more complex as our experience with supplying bridge steel increases."

Burnco won the bid to supply steel for the Canadian approaches to the bridge. The steel was needed to create a super elevated connection between ground level and the main span of the bridge. The company supplied girders for the approach that were up to 37 metres in length.

"One challenge was that each of the girders had to be made with a horizontal curve or sweep of 61 -92 centimetres," says Boote. "The sweep required special jigs to create. We essentially worked through a 3D fabrication process versus the normal 2D approach." The girders were non-weathering, which was consistent with most of the steel supplied for the bridge because of a three-coat paint applied after installation.

"Being a part of this project is a once-in-a-lifetime experience," states Boote. "All the steel we supplied was from Canadian producers which is a good news story for our country."

"Being a part of this project is a once-in-a-lifetime experience. All the steel we supplied was from Canadian producers which is a good news story for our country."

– JOHN BOOTE

Photo credit: Windsor-Detroit Bridge Authority.

The CANAM Group

The CANAM Group has been operating for more than 60 years. With 3,500 employees, the company specializes "in the design and manufacturing of metal components for the construction industry in North America, operating in the fields of buildings, metal frames and bridges."

CANAM is supplying the steel for the main span of the bridge. "This includes 70 robust anchor boxes, 216 stay cables anchorage and 224 edge girders, intricately woven into the fabric of the bridge," says Mathias Dutil, project manager with CANAM's bridge division. "The structure is further strengthened by 315 floor beams, 624 cladding panels, 942 redundancy girders and 1,256 soffit panels, cumulatively weighing 28,560 metric tonnes."

The challenge in supplying steel for the project was the delay caused by the pandemic. When the pandemic receded, construction was sped up to make up for the lost time. CANAM had to increase their factory output and shipping schedule to ensure the steel was available for the new construction timeline. "For a time, it became a very complicated process to manage as bridge construction tried to catch up," says Dutil.

"Moving large objects like the Gordie Howe Bridge girders is something we do every day, and we have processes and partners that we use to navigate the challenges of heavy hauling."

– ALLISTER MOOD

"Our company knows how important this project is to Canada and the U.S.," says Dutil. "We are proud of our contribution and have kept our employees aware of the bridge's progress since the construction began."

Cherubini Bridges and Structures

Since new ownership took over Cherubini in 1967, the company grew from a manufacturer of steel staircase railings to "a leading Atlantic Canadian steel fabricator, designing, producing and delivering bridges and complex structures around the world." Based in Dartmouth, N.S., Cherubini has two factories that fabricate bridge construction steel in Burnside and Shearwater, N.S.

Cherubini supplied the steel for the U.S. approaches to the bridge. Similar to the Canadian side, the company supplied girders to connect the main span of the bridge to the ground. "The girders are up to 43 metres in length and each required fabrication of a horizontal curve on one end," says Allister Mood, project manager with Cherubini Bridges and Structures. "Our company also supplied braces for the girders and diaphragms to stiffen loads at the piers."

"The project was reasonably straight forward; the fabrication was relatively simple, and coatings are a typical three-coat system that we work, with every day. Perhaps if we were forced to pick something as the most challenging portion of the work, we might say that the logistics required a high level of effort to ensure the deliveries of the girders went smoothly and without delay," says Mood.

He adds "Moving large objects like the Gordie Howe Bridge girders is something we do every day, and we have processes and partners that we use to navigate the challenges of heavy hauling. The distance is about 2,100 kilometres, and each province and city the steel moved through required special permits." They used the Detroit ferry for the last part of the trip to the U.S. side of the bridge until it shut down in the fall of 2023. This required the company to cross the U.S. border at Sarnia – a lengthy distance increase.

"It was great to have three Canadian fabricators providing steel to a major international project of this magnitude," said Mood.

Due to the pandemic delay, the Gordie Howe International Bridge is forecast to have the construction completed in September 2025. It will be the largest cable-stayed bridge in North America. For more information, go to www.gordiehoweinternationalbridge.com. AS

Photo credit: Windsor-Detroit Bridge Authority.

ANDREW VOTH
Ph.D., P.Eng., Associate
RJC Engineers

TD TERRACE

Collaborative steel solutions for a sculpted skyscraper

BY :: ANDREW VOTH, PH.D., P.ENG., ASSOCIATE, RJC ENGINEERS (AVOTH@RJC.CA, WWW.RJC.CA)

The City of Toronto's already dynamic skyline has once again been enhanced with the addition of a new sculpted and sloped skyscraper: TD Terrace.

Located at 160 Front Street West at the corner of Front and Simcoe Streets, the newest space for TD Bank is a 47-storey, 240-metre-tall sloping steel-framed commercial tower that adds approximately 1.2 million square feet of Class A office space to Toronto's financial core. Along with the incorporation of a six-storey masonry heritage building façade, the building offers four levels of below-grade parking and bike storage with a dedicated underground PATH connection and a four-storey podium with tenant amenities, set to be occupied in 2024.

From its beginning, Adrian Smith + Gordon Gill Architecture designed the tower's unmistakable sculpted silhouette to be a response to the local environment. By orienting the main axis of the building parallel to the site's prevailing winds and tapering the building at both the top and bottom, the wind's lateral loads on the structure are minimized. The shape of the building also had a significant impact on the pedestrian realm by minimizing wind effects at grade and creating a spacious landscaped area in stark contrast to the compressed neighbouring sidewalks. The irregular shape, the client's vision and the demanding structural requirements of this unique building also created many challenges that could only be overcome with the use of innovative steel solutions and significant collaboration between RJC Engineers and Walters Inc.

Advanced Steel for Complex Geometry

Developer Cadillac Fairview with Adrian Smith + Gordon Gill Architecture and B+H Architects began working on the project over 10 years ago with key features in mind, including state-of-the art façade, sustainable strategies, efficient use of space and speed of construction, among others.

The use of structural steel had significant advantages to addressing some important requirements of the project. A hybrid structure approach with a concrete core, structural steel framing (approximately 9,500 tonnes) and structural steel outriggers has a significant advantage for speed of construction over a conventional all-concrete structure.

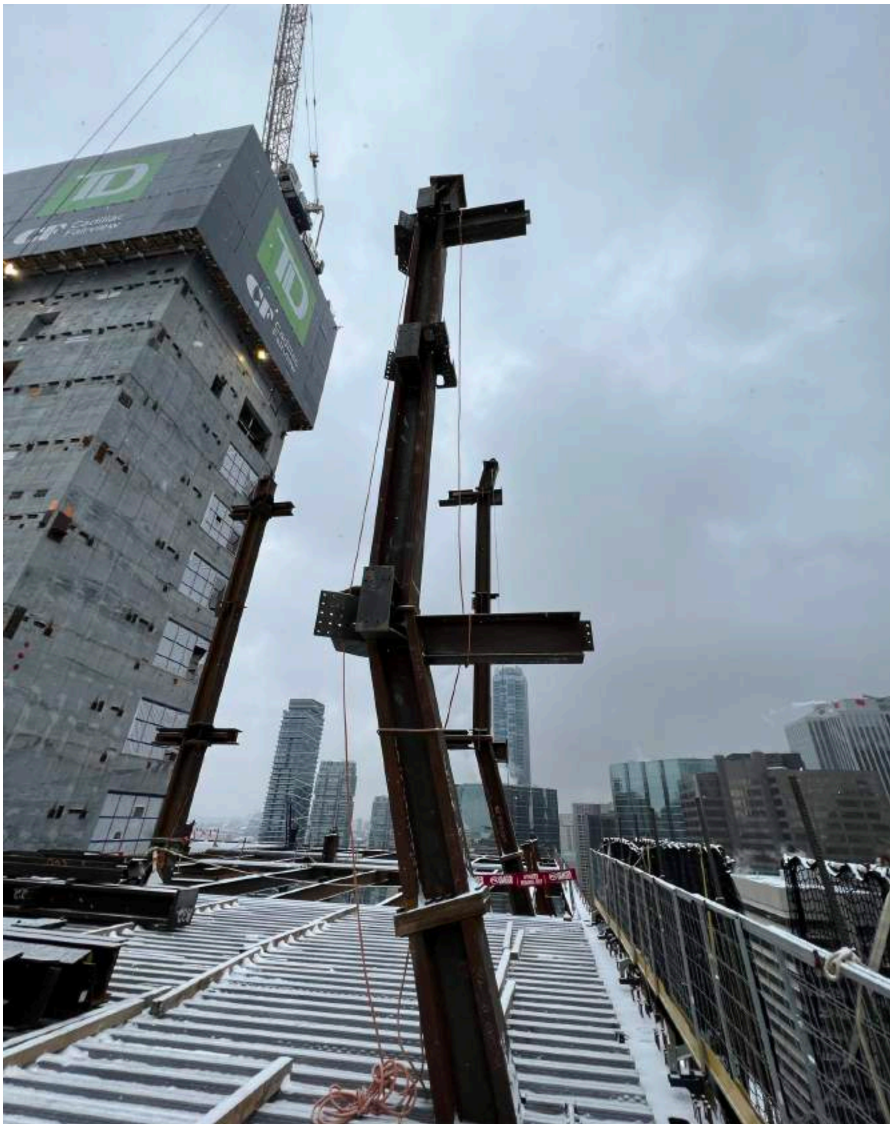
Structural steel also provides the ability to create large column-free spaces by allowing long floor plate spans between the concrete core and the perimeter façade. Spans between 13 metres and 15 metres varied over the height of the building and were important to form the complex sloped geometry of the building, and also to provide efficient tenant spaces. Structural steel, because of its high strength-to-weight ratio, was also important in keeping the structure as minimal as possible, including keeping column sizes relatively small compared to concrete construction.

Beyond the more typical reasons why steel was the best material for the TD Terrace, structural steel was critical in making the complex building geometry possible in three areas: the sloping geometry of the building façade, the architectural feature "inlets" and the curved crown volume at the top of the structure. The structural challenges of the building's complex geometry also led to fabrication and connection challenges, where a close collaboration between Walters and RJC Engineers was essential to make the project a reality.

A Team Approach to a Challenging Design

No project is without design challenges, but 160 Front was unlike any other that required close collaboration between engineer and fabricator to make the architectural intent a reality.

The tower's sculpted sloped shape required that the perimeter steel columns were sloped for the entire building height. Column geometry changes occurred at approximately every three floors and spliced one metre above the floor (as opposed to at floor level) to allow for better erection accessibility. With each change in column slope the structural steel floor plates resolved the unbalanced "kick" force back to the concrete core. Very early in design, working points of the change of inclination of the columns were coordination between the architects, Walters and RJC to ensure the splice locations minimized the structural impact, lifts were within crane restrictions and splices were in locations well suited to fabrication, all while still maintaining the architectural intent.



Developer: Cadillac Fairview
Architect: Adrian Smith + Gordon Gill Architecture & B+H Architects
Structural Engineer: RJC Engineers
Steel Fabrication and Erection: Walters Group
Constructor: PCL Construction

An extreme set of inclined columns was required at the tower inlet floors: an architectural feature where the building face steps back on the east and west sides of the tower to create a mid-tower terrace. The significant column-cranked offset of 2.5 metres over two floor levels creates a significant axial force in the steel floor diaphragm and, eventually, into the concrete core. This combined with differential movement between the structural steel columns and the concrete core creeping over time required innovative steel connections. Two details were developed to ensure efficient axial force transfer, and also to limit significant bending on the shallow axial members created by the differential movement.

The high axial force connection between floor diaphragm and the concrete core required pre-stressed Dywidag rods embedded in the core walls. The design team determined that a "true pin" connection between the rods and the structural steel was the best approach to limit member bending due to vertical core movement and to develop the large axial force connection – a connection that could only be realized in steel. The pin detail and the Dywidag stressing sequence was also an iterative process, with Walters and RJC Engineers working through connection clearances, dead and live stressing end locations and the best configuration of the pin itself – a challenge that could not have been overcome without collaborative design and planning and the use of a structural steel system.

Top It All Off

The iconic tower is topped with a 45-metre-tall curved structural steel volume that is home to a 23-metre-tall glass architecturally exposed atrium with exposed CastConnex Diablo connections, a building maintenance unit including a 12-metre wide operable sliding door and the mechanical penthouse levels. Beyond the curved structure being geometrically complex where only structural steel is really an option, the space is also home to a critical part of the building's lateral system: a series of inclined outriggers at the top of concrete core that help control the lateral drift of the building.

To ensure that the columns that were a part of the outrigger system did not pre-compress by being pushed down by the shrinking/loaded core, the outriggers were axially released to be locked in six months after the core topped off. The location of the release was modified to ensure that the locking in could take place effectively, understanding that the top portion of the outriggers were exterior, and bottom portion were positioned in a tight mechanical level with equipment fully in place. PCL and Walters' sequence played a large role in determining the best approach with RJC.

The outrigger system included embedded steel sections in the core walls, and very detailed BIM modelling from Walters (down to the couplers) was done to minimize the clashes with the preferred connections, reinforcement and climbing formwork system jack locations. A significant challenge where collaboration was key to success.

Collaboration: Key to Success

160 Front's exterior elegance has a complex structural system skeleton that could not have been possible without the use of structural steel and significant collaboration from the whole project team. Collaboration relies on a culture of willingness to collaborate and work through challenges at various points in the life of a project, and also looking for opportunities over the course of a project. TD Terrace is a wonderful example of how an innovative, collaborative structural steel design can produce an iconic, inspiring project in reality. AS

UNLOCKING THE SECRETS OF STEEL ROOFING LONGEVITY

Tips for a durable investment

BY :: SARAH MAJLESI, SENIOR ENGINEER, CFS, CISC-ICCA

Steel roofing options are becoming more and more popular in various construction sectors, especially the residential market, and one of the first characteristics that come to mind when describing steel roofing as a building material, as opposed to other building materials, is "longevity." Several factors contribute to this important character of steel roofing which we will discuss in the form of a three-part series, with each property reviewed and elaborated on in each publication.

Durability under extreme weather conditions: This will be elaborated further in part two of this article. There are various testing and insurance companies which provide structural requirements and demands for withstanding catastrophic weather impacts.

Coating/galvanization: Information on various coating designations will be covered in part three of this article.

Engineered system: This may not seem obvious at first, but cold-formed steel roof cladding systems are made of tough and high-performing building components that withstand environmental and human demands over the course of the specified design lifespan. The calculation of gravitational as well as lateral loads from applicable building codes, load patterns and how they distribute within the system and supporting structure are just some examples of what the specialized cold-formed steel engineer considers when designing the roof structure. This, in essence, is different from the specifications; i.e., water penetration, energy modelling and other building envelope requirements.

A big part of engineering roofing systems is working out the load distribution amongst the interconnecting components. Thermal deflection is also of concern, and one could expect a one-mm expansion per metre length of sheet steel. Thermal load contraction and expansion review is outside the scope of this article; however, it is essential to know that the designer must be aware of the fact that there are thermal displacement structural calculations based on temperature changes available, and point of cladding to subgirt attachments must account for the displacements. This may be assumed at eave or ridge level, however, the sliding snow stiffener location may have an impact on where this is located.

Wind uplift, as well as sliding snow and normal-direction projected snow load, create the most significant impacts to the steel roofing. Deflection criteria are normally set as L/360 and L/240, with L being the steel roof cladding span. Roof cladding withstands wind uplift through the seam clips, which in turn is transferred to the structure via substructure (steel subgirts), roof deck and associated attachments. Seam clips are either penetrated or non-penetrated, depending on the architectural requirements. Snow load is projected into two

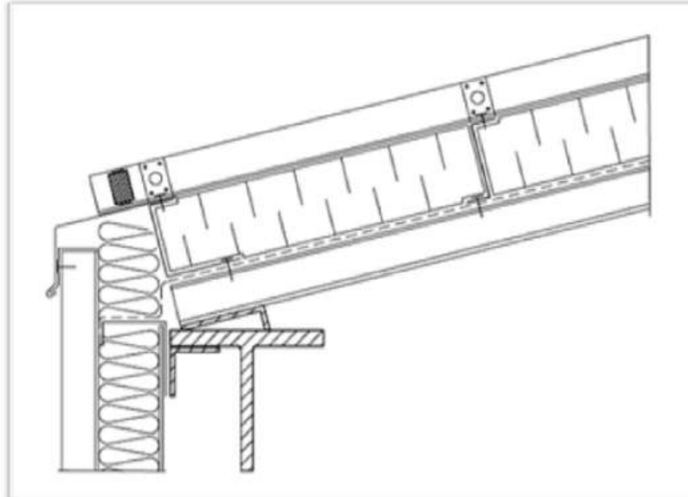


FIGURE 1: Typical cold-formed steel roofing assembly.

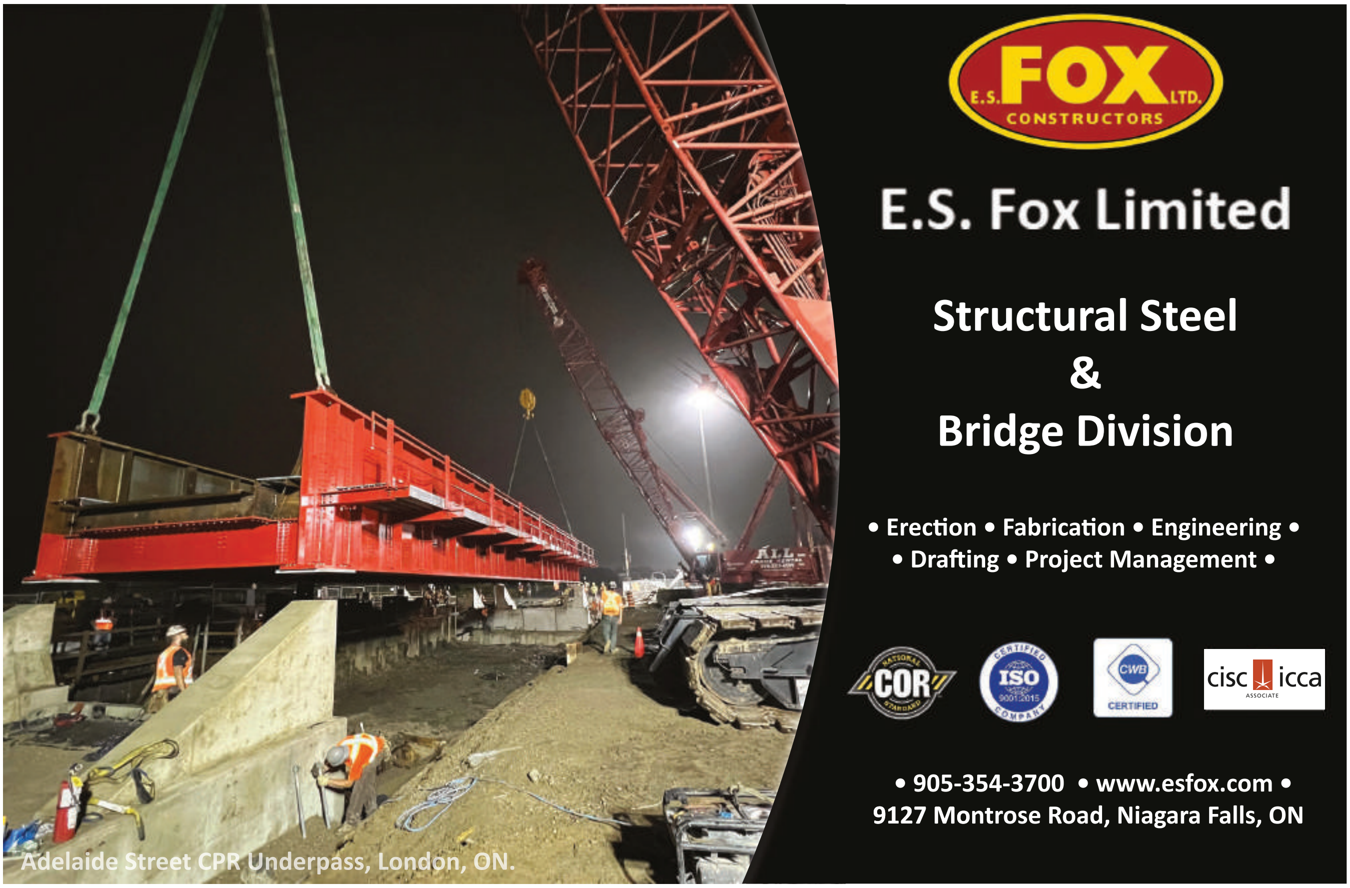
directions. Normal (perpendicular) direction gets distributed through the roof onto the sub-girts (or insulation, depending on the rigidity) and then the roof decks and purlins. Sliding snow however – depending on the load magnitude – is either taken on via through-fastening of the U-subgirt at the eave or, in higher snow loading cases, through sliding snow stiffeners.

CSSBI S11-15: Insulated sheet steel roof assemblies is a fantastic resource for steel roofing assemblies, installation techniques and the various parts and components associated herein. The various components described above are shown in Figure 1. Many of the indicated components are proprietary and specific to the roofing manufacturer, often dependent on testing and engineering judgement for structural capacity determination. It is considered good practice to contact manufacturer design offices and enquire on specifications and associated typical details. An example of this would be the design specifications for subgirt steel thickness or spacing, which come down to manufacturer-specific data (i.e., wind uplift pull-out capacity).

Another important aspect in steel roof assembly designs is the coordination between the consulting engineer and the specialty cold-formed engineer (manufacturing). Through practice, manufacturers and consultants alike can produce and assemble roofing as seamlessly as possible. As an example, providing the following information to the manufacturer can help achieve this:

- **Full structural design loads and design criteria:** Helps achieve a unified approach in the determination of structural components. Steel claddings impose a wind load derived from components and cladding coefficients that are different to wind loads calculated for framing members.
- **Insulation compression strength:** Load-bearing capacity of insulation has an effect on the gravitational structural capacity of subgirts.
- **Specification of other structural material:** Specification of other common building material such as wood should be provided as applicable (pressure-treated, thickness, grade, etc.)
- **Details, specification and design** thickness of all roofing assembly supporting members.
- **Mechanical attachments:** Loads and location to sprinklers, ducting system and vent hoods must be indicated.
- **Roof fall arrest and snow guard requirements:** Manufacturers often have preferred products and anchorage methods compatible with their products.

As described above, there are various architectural and engineering design provisions to follow for specifying a steel roof cladding system. Following them will ensure the end user to have a moisture/heat-controlled roof system that is visually pleasing and durable with outstanding load-bearing capacities. AS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SUSTAINABLE DEVELOPMENT

Advocating for structural steel reuse in construction

BY :: ISIS BENNET, M.A.SC., P.ENG., STRUCTURAL ENGINEER, WSP

Designers and engineers are being challenged to minimize the environmental impact of their projects. Canada's net zero by 2050 target and existing and developing municipal standards are ambitious and will take creativity and commitment to achieve.

By incorporating structural steel reuse, bypassing the energy-intensive recycling process, designers can reduce the material's embodied carbon in their projects by about 95 per cent. The adoption of this circular economy approach in the structural steel industry will reduce waste, conserve resources and minimize its environmental impact. Embracing this practice will contribute to a more resilient and sustainable construction industry and help meet the demands of a growing sector without compromising our environment.

Reuse of structural steel is at a turning point – it's gaining traction in the U.K., with a handful of active projects and established salvaged steel stockists. This follows the 2019 release of a U.K. protocol, Structural Steel Reuse (P427 and addendum P440), by the Steel Construction Institute (SCI). Despite its rise in the U.K., it remains uncommon in the Canadian market. Strengthening sustainability targets in Canada are increasing demand for innovative solutions from clients, and advances in computing power and machine learning provide an opportunity to streamline the steel reuse process.

The ongoing Centre Block Rehabilitation (CBR) project in Ottawa is a case study that demonstrates the structural steel reuse process in a Canadian context, where the iconic parliament building is undergoing significant rehabilitation to meet modern parliamentary requirements. As part of this rehabilitation, new steel structure is being introduced alongside the original 1916 structural steel; most of the historic steel is retained in-situ with a subset requiring removal. Preliminary investigations verified that the steel is generally in good condition, informing the decision to salvage in lieu of recycling. This initiative identified approximately 1,700 beams with reuse potential in the new construction phase of CBR, equating to 625 tCO2e in embodied carbon savings.

To incorporate the salvaged steel in CBR, our team at WSP Canada specified deconstruction requirements, developed comprehensive inspection processes, outlined an inventory framework and established a workflow to integrate the salvaged members into the new design. Identifying suitable locations for the reuse of steel posed a challenge given the impracticality of manually cross-referencing 1,700 salvaged beams with the new design. Therefore, we developed our own software that identifies each unique salvaged member and finds suitable locations for reuse in the new design. This tool optimizes the "matches" where the salvaged steel can be reused and automatically updates the construction drawings via Revit integration. This tool enabled our design team to quickly assess the overall match quantity and quality at multiple stages in the design, which otherwise would be prohibitively time consuming with such a large sample size.

Based on current projections, the reuse of structural steel on CBR is cost neutral. On this project, there was additional abatement work required to remove a lead coating on the beams. Despite this, the cost to deconstruct, track, inspect, abate and store the steel is offset by reducing the quantity of purchased new steel. Looking beyond this case study, this suggests that steel reuse can be cost-effective in a wide range of project scenarios, from historic to modern. As the industry adoption increases, and processes become more efficient, we can expect costs to owners to improve.

Lessons learned from this case study underscore the importance of early identification of a steel source. The project schedule must give enough lead time to identify a steel source, which could be in a building not yet demolished, which will require extra care to deconstruct and salvage. Early testing of material properties and identification of member sizes and lengths informs designers and enables them to efficiently incorporate salvaged steel into the design process. Designing to the available salvaged steel source can lead to opportunities for many creative solutions, such as subdividing salvaged members for use in multiple locations or altering the structural layout to maximize steel reuse.

Automating the process of matching salvaged steel members is instrumental on large projects where a manual approach is impractical. A good algorithm can determine the best overall match when multiple potential reuse solutions are available, leading to more efficient and sustainable material use. Furthermore, an automated matching tool can be used to quickly assess the compatibility of a salvaged steel source with a project that is considering reusing steel.

From a designer's perspective, we should be encouraging the wider adoption of salvage and reuse of structural steel. The CBR case study relied on the owner's existing steel building as a salvaged steel source. To extend this practice to conventional projects, where the owner does not have a pre-existing stockpile of salvaged steel, a salvaged steel market needs to be established where designers and/or fabricators can source and specify the reuse of steel. Standardization would facilitate the development of such a market by giving designers confidence in the material quality. This would include information on steel tracking, documentation, testing and inspection criteria. Standardization would also help stockists ensure that their product is marketable and can inform the choice between salvage and recycling on demolition jobs. The CISC is in an ideal position to establish a best practice guide for structural steel salvage and reuse in Canada, similar to what has been published in the U.K. This guide could serve as a valuable resource for all stakeholders involved in construction projects. Ultimately, we at WSP advocate for a paradigm shift towards embracing structural steel reuse as a mainstream practice in the Canadian construction industry. This is in alignment with Canada's 2050 net-zero goal and WSP Canada's commitment to reach net-zero greenhouse gas emissions across its value chain by 2040. AS

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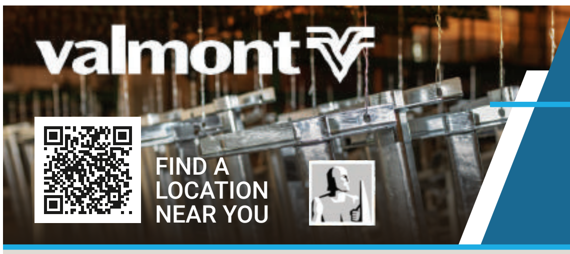
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