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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: Ravens Eye Cliff Walk - Whistler, BC

Photo courtesy of Rob Third, George Third & Son



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Living Trees Sequester CO₂ Not Lumber Materials, Study Shows

THERE IS AN OLD saying that if you torture your data long and hard enough you can get it to say anything. Add in a bit of alternate facts, untruth truths, repeat messages on social media and government(s) to the mix, and you have a recipe for disaster. Which brings me to the debate on climate change. While governments around the world are developing all sorts of policies to try to reduce greenhouse gases, the wood industry claims it can save the planet.

In general, we can all agree that something has to be done, but it is how it is done that burns many.

Enter the wood industry, the knight in shining armour, with a solution to make all the greenhouse gas problems go away. Their solution is to increase the area forested annually, grow lots of trees, cut them all down, grow more trees, cut them all down and repeat and repeat as fast as possible. They believe that all that wood will soak up all the CO₂ and sequester it for all eternity in a house or building. An idea so beautiful and so simple - why wasn't this thought of before? Add this to their claims that wood doesn't burn, it only chars (tell that to the millions of campers around the world — how would we cook our s'mores!); wood is renewable; and the wood industry employs many Canadians. You can see why governments are lining up to drink the KoolAid... or should we call it WoodAid.

But let's stop and take a closer look at just some of the realities and the little know facts that are hidden in the closet.

If we were to use more wood in construction in Canada, we would need access to more Canadian forests. I hope they are not going to import wood! Or are they? Will this move truly benefit Canadian companies and Canadian jobs? The wood industry (if they have their way) will replace the current steel, concrete and brick construction, as well as the jobs within each industry, and turn more of Canada's forests into timberland. Existing logging is already having a profound impact on forest ecosystems and biodiversity; just imagine the ramifications when they ramp it up! But governments aren't measuring ecosystems and biodiversity. They care only about greenhouse gas emissions at the moment. I would love to see a debate with the David Suzuki Foundation and the wood industry on this one.

Increased logging will also affect the world's carbon cycle, since old-growth forests are currently responsible for sequestering billions of tons of carbon every year and can continue to do so until they are 800 years old.¹ These impacts mean that increasing the use of wood, and therefore the amount of timberland, will have a considerable effect on the world's ecosystems and climate and should be considered carefully. In fact, reducing the amount of timber harvested in some areas can have tremendous environmental benefits. A study by researchers at the University of Washington on the management of Oregon's forests found that reducing the amount of forest land which is logged and lengthening the harvest cycles in the remaining timberland could increase the amount of carbon stored in the forests by more than 50%. The study also showed that this change would store carbon much more effectively than wood products because forests can retain the carbon for much longer, and that the reforestation would be accompanied by many other benefits, such as increased water availability and biodiversity. Since that study also found that the wood industry is the single biggest source of carbon emissions in Oregon, such changes could have a profound impact.²

Wow! You will never hear the wood industry reference that study.

So, how much of the tree is actually transformed into wood products? As little as 20 per cent of the original tree end up in primary and secondary construction products. The balance, mainly stumps and branches, are left to decompose, are combusted or end up in short-lived products. After 100 years, as little as 1% of a tree's carbon remains in construction products that are still in use.³

Interesting: when wood decomposes it releases CO_2 and methane (28 times more potent than CO_2).

So, after 100 years, 99% of the tree is gone, out of use, burned, rotted or rotting. It has released all the CO_2 back into the environment, and even worse, has produced methane. You call this a good solution? Add to this the mountain pine beetle which has killed or is in the process of wiping out most of the logging forests in British Columbia and Alberta and

is poised to spread east to the Boreal forest. So much for being renewable! Oh, wait, it gets better. Guess what the proposed use is for much of this beetle-killed wood? Wood pellets for electricity, of course! Which, simply put, is the burning of wood and releasing of CO_2 . Such an environmental bunch, those wood guys!

And don't get me going about the fact that wood no longer looks like wood. It seems like it is more glue and plastic than it is wood these days. Of course, only environmental glues and plastics. You can eat it just like Agent Orange. And I'm sure glues and plastics don't burn either, they only char.

Well, so much for wood carbon sequestering, boys and girls. Many will buy into this green leafed pile of wood dust, but that is the world we live in at the moment. The world is flat, and wood doesn't burn. It's no wonder why our kids are fed up and are camping on the lawns of legislatures around the world. Big business is spinning the truth and the only ones seeing the truth are the ones we are trying to protect from the truth.



1 Luyssaert, S, et. al. 2008. "Old-growth forests as global carbon sinks," Nature doi:10.1038/nature07276.

2 Law, B, et. al. 2018. "Land use strategies to mitigate climate change in carbon dense temperate forests," Proceedings of the National Academy of Science, https://doi.org/10.1073/ pnas.1720064115.

, 3 Ingerson, A. 2019, Wood Products and Carbon Storage: Can Increased Production Help Solve the Climate Crisis? Washington, D.C. The Wilderness Society.





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

CISC provides this column as a part of its commitment to the education of those interested in the use of steel in construction. Neither 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 professional engineer, architect or other licensed professional.

Question 1: Is the use of clipped double connections a requirement in CSA S16-14?

Answer: No. But clipped connections are required by the CISC Code of Standard Practice for Structural Steel in some situations. Clause 5.2.2 states: "Where two beams or girders, framing at right angles from opposite sides of a supporting member, share the same bolts, a clipped double connection shall be used unless a seated connection or other detail is used to facilitate safe erection of the beams or girders."

Clipped end connections are also required by some provincial regulations. In Ontario for example, the requirement is found under the *Occupational Health and Safety Act* – Construction Projects.

Commonly used clipped connections include end-plate (see Figure 1) and double-angle header beam connections. Alternatives to clipped connections, such as shear tabs, may be used when possible.

FIGURE 1:



Question 2: I'm renovating a steel-framed building containing welded-wide flange (WWF) sections. Since these shapes are no longer listed in the Handbook, where can I find design information?

Answer: Algoma Steel Inc. was the prime producer of welded shapes until production discontinued in late 2010. WWF beam and column shapes are generally not carried in inventory.

The most recent set of properties and dimensions tables was published in the 10th edition of the Handbook and can be found in the CISC Steel Design Series – Part 4. The first series of welded shapes produced in even metric units and introduced in 1976 can be found in Part 5. The Steel Design Series may be downloaded at this link: www.cisc-icca.ca/cisc-steeldesign-series/

WWF sections published in the 1st edition Handbook (1967 – imperial units) can be found in the Technical Resources webpage: www.cisc-icca.ca/ technical-resources/

<u>Question 3:</u> Why is the plastic section modulus not given for channel sections in the Handbook?

Answer: Values of the plastic section modulus (Zx or Zy) are not included among the section properties in Part 6 mainly because channels are considered Class 3 sections in CSA S16-14 Clause 13.6(b). The moment resistance is calculated using the elastic section modulus (Sx or Sy).

Clipped end connections are also required by some provincial regulations. In Ontario for example, the requirement is found under the *Occupational Health and Safety Act* – Construction Projects.

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.

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Prompt Payment

By Richard Woodbury

A STEADY CASHFLOW is the lifeblood of any successful business.

Without it, even quality companies can go bankrupt and firms aren't able to reinvest in their businesses through buying new equipment or hiring more employees.

The need for prompt payment legislation is one of the biggest challenges in the construction industry, but the situation is improving. CISC has been working tirelessly to drive the move through advocation at the federal and provincial levels.

Prompt payment and adjudication legislation is being developed and implemented to ensure tradespeople are paid within 30 days, which is a huge step forward from the current 90 days.

Progress so far

Thanks to the ongoing advocacy efforts of CISC, Ontario enacted prompt payment legislation through reforms of the existing *Construction Lien Act* in December 2017. Bill 142, the *Construction Lien Amendment Act*, established the first prompt payment regime in Canada and created a standard for other provinces to follow.

A government press release at the time noted that between 2002 and 2013, the average collection period in the construction industry increased from approximately 57 to 71 days.

"These changes will have a real impact on people's lives, giving workers assurance they will be paid on time and in full, and help to ensure disputes are resolved quickly," said Yasir Naqvi, then the province's attorney general.

That same month, Quebec passed Bill 108, which facilitates oversight of public bodies' contracts and allows the provincial government to implement pilot projects to test different construction law reforms for public contracts and subcontracts, including prompt payment and adjudication.

Last November, federal Finance Minister Bill Morneau said the federal government was committed to passing prompt payment legislation.

This was an update from a January 30, 2018, announcement from Public Services and Procurement Canada in which it declared it was seeking industry input and recommendations for federal legislation. Two independent experts were retained to gather input from the construction industry.

"Today, our government is taking the next step in ensuring that subcontractors who work on federal construction contracts get paid on time," Steven MacKinnon, the parliamentary secretary to the minister of Public Services and Procurement, said at the time. "The construction sector is an important employer and economic engine in Canada. Our government is committed to ensuring that construction investments flow efficiently to all contractors involved in federal projects."

As part of the consultation process, CISC played a pivotal role, providing valuable recommendations advocating for the importance of timely payments.

The two independent experts, Bruce Reynolds and Sharon Vogel, wrote a report released last summer.

"We have concluded that the existing prompt payment policies and/or proposed voluntary codes are inadequate to achieve prompt payment, particularly at the trade contractor level and below, such that the implementation of prompt payment legislation at the federal level makes sense," the authors wrote.

They said there were three reasons legislation was needed:

- To "assure the orderly and timely building of federal construction projects by ensuring that cash flows down the construction pyramid quickly, thereby avoiding the disruptive effects of delayed payment, and potentially non-payment."
- To reduce construction costs caused by trade contractors who add contingencies to their bid prices to account for the costs that come with slow payments.
- To reduce the risk of projects being disrupted because of contractor and subcontractor insolvency.

In the March 2019 federal budget announcement made by Morneau, the Government of Canada further solidified their commitment to the implementation of federal prompt payment legislation and adjudicative measures.

On March 15, 2019, the Nova Scotia government introduced prompt payment legislation. This legislation is intended to provide the authority for establishing an adjudication process to resolve disputes faster when timelines are not met. Interest rates will be established for payments not made on time. Soon after, early in April 2019, Nova Scotia's Bill 119, the *Builders' Lien Act* (Amended) received royal assent and was enacted.

In Saskatchewan, the provincial government tabled amendments regarding prompt payments on November 20, 2018. "Under the proposed legislation, owners and developers will be required to provide payment within 28 days of receiving a proper invoice for construction services," noted a government press release. "Contractors will be required to provide payment to subcontractors within seven days of receiving a payment from the owner or developer."

Since then, the Legislative Assembly of Saskatchewan passed the third reading of *The Builders' Lien (Prompt Payment) Amendment Act.* As of May 2, 2019, Saskatchewan is the third province to enact prompt payment legislation, alongside Ontario and Nova Scotia.

Elsewhere in Canada, efforts are ongoing to bring about prompt payment reforms.

In B.C., the British Columbia Law Institute is reviewing the province's *Builders' Lien Act* in an effort to reform it.

In New Brunswick, the province is considering adding a prompt payment and expedited dispute resolution scheme to the province's main construction law statute, the *Mechanics' Lien Act*.

Ed Whalen, CISC's president and CEO, says that prompt payment legislation with adjudication is one of the most important and needed measures for the Canadian construction industry. "Ontario was the first to achieve this goal and we are seeing the dominos beginning to fall across the country." "Today, our government is taking the next step in ensuring that subcontractors who work on federal construction contracts get paid on time."

- Steven MacKinnon, parliamentary secretary to the minister of Public Services and Procurement





Michael Holleran, P.Eng. Canam Buildings and Structures

Structural Steel Management and Detailing

THE LACK OF SKILL TRADES remains

a constant concern, regardless of the sector or region that you reside in within the steel construction community. Steel construction has been at the forefront of innovation, moving from drafting pencils to 3D modelling and from saw-horses in fabrication shops to robots. Change is a constant. With this change, new skills are required.

The Education and Research Council (ERC) is proud to support a two-year graduate certificate program at Conestoga College in the Waterloo region of Ontario. Under the engineering department, this 16-month program titled Structural Steel Management and Detailing (SSMD), gives students the opportunity to specialize in the detailing, supply, fabrication and installation of steel structures, including the management and coordination of projects. The training being offered was created by industry professionals to enable students to develop the analytical and communication skills to have an excellent foundation in all aspects of steel detailing, design, supply and management. The learning environment is founded on project-based learning principles and includes discussions groups, seminars, site visits and practical assignments. As part of this program, a co-op work study semester has been introduced to improve the students' practical learning. Several CISC members gladly accepted co-op students for a work term.

The first cohort began in January 2018, with an enrolment of 25 students with great success. The 2018 cohort will be actively seeking employment



in April 2019. The second cohort that began in 2019 has an enrolment of 28 students. Rigorous prerequisites were put in place to enter the program, making the attributes and knowledge of the graduates sought after by many companies within the steel community.

Please contact Conestoga College should you wish to take advantage of this opportunity of these skilled professionals to help progress and navigate your company through the years to come.

Once again, please consider supporting the ERC to ensure initiatives like the SSMD program continue, and to ensure the growth of the structural steel industry is strong for the next generation. Please contact the CISC for more information on how your funding can directly support education and research in the steel industry.

"The training being offered was created by industry professionals to enable students to develop the analytical and communication skills to have an excellent foundation in all aspects of steel detailing, design, supply and management."

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Developing Talent and Driving Innovation

Lydell Wiebe, Associate Professor, McMaster University

AS AN EDUCATOR and researcher, my main job is to create opportunities for students to develop knowledge and skills that will last them a lifetime. By creating the right environment, we engage a diverse range of people to develop their skills so that they can tackle the challenges of a rapidly changing industry.

Education: Developing talent in the next generation

The CISC's Education and Research Council (ERC) plays a key role in creating this environment to set top students on a track toward a lifetime of contributions to steel construction. This ecosystem involves undergraduate students, graduate student researchers who also work as teaching assistants, and faculty who teach what they need their students to know in order to conduct their research.

One of the ways that the ERC makes this possible is through the CISC Research Grant program. Most of this funding goes toward graduate student stipends, making it possible for top talent to spend some of the most formative years of their lives focusing on steel. These graduate students also engage with undergraduate students, sharing their passion for steel.

Research: Driving innovation to stay competitive

Not only does steel-focused research create a climate that engages students in steel construction, but it is also a key driver of innovation in the industry. Certainly, CISC members are already innovative, implementing new technologies in all stages of design and construction. At the same time, some challenges are bigger than any one CISC member. For example, in my main research area of earthquake engineering, a transformation toward performance-based design is underway. This uses advanced modelling to predict how structures will respond to earthquakes, so that we can not only make structures safe during an earthquake, but also return structures to service rapidly afterwards. This kind of revolution spans the entire construction industry, requiring fundamental differences in how structures are designed and built.

In every structural material, new ways are being developed to build taller, safer, cheaper, more resilient and more sustainable. The support of the ERC is critical in ensuring that steel does not get left behind.

Support education and research in steel

So what can you do to support this education and research? First, get connected! Maybe you could donate some materials, maybe you're looking for excellent co-op students or new graduates, maybe you could invite a class for a tour that showcases steel construction, maybe you would like to support a scholarship for students who focus on steel. Whatever it is, I'm sure your local university and college would love to hear from you.

Second, continue supporting the good work of the CISC's Education and Research Council! By bringing together resources and expertise from CISC members across the country, the ERC is at the core of an education and training environment that can continue to develop new leaders to drive innovation in steel construction.

"Certainly, CISC members are already innovative, implementing new technologies in all stages of design and construction. At the same time, some challenges are bigger than any one CISC member."

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Congratulations Pedram Mortazavi!

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"I AM VERY pleased, honoured and humbled to be named the 2019 recipient of the G.J. Jackson Fellowship. It is a great privilege to have my name next to such

high-calibre and distinguished professionals who have been the former recipients of this prestigious award. I know some of the former recipients personally and some of them by reputation. I am aware of their exceptional contributions to the steel industry in Canada and beyond, and it is a true honour to have my name in the same list as them. I am very thankful and grateful to the G. J. Jackson Committee for this unforgettable recognition, which will be a strong source of motivation, not just for the completion of my Ph.D., but for the rest of my career. This achievement would not have been possible without the constant support of my research advisors, Professors Constantin Christopoulos and Oh-Sung Kwon and their guidance along the way.

My Ph.D. research project is focused on the experimental validation and performance assessment of Cast Steel Replaceable Link Elements in Steel Eccentric Braced Frames (EBFs). The project is aimed at the development of off-the-shelf products, that when used by engineers, will significantly improve the seismic performance of EBFs through increased ductility and rotational capacity. Further, use of the proposed product in EBFs is expected to remarkably simplify their design process, constructability, and potential repairs, through replaceability. This is a joint project between the University of Toronto and CISC member Cast Connex, an industry leader in the design and supply of cast steel components in steel structures."

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CISC STEEL CENTRE

As it continues to challenge traditional boundaries

By Robert Driver and Matt Jepsen, CISC Steel Centre



HITS THE ROAD



THE CISC STEEL CENTRE, an industry-academic hub for education and research at the University of Alberta in Edmonton, took wing to the West Coast this past November. Graduate students and professors visited a number of notable steel construction projects and learned firsthand from the engineers and fabricators behind them. The Steel Centre travelled to Vancouver and Seattle, partnering with firms in the area to get backstage access to the design and construction process for awardwinning steel structures. This unique learning opportunity exposed students to the realities of steel construction throughout the process chain, and inspired these young engineers to strive to create exciting and technically impressive steel structures in their future practice—perhaps even winning a CISC Steel Design Award of their own!

Students and professors from the Steel Centre learned from a week of back-to-back visits with fabricators, consultants, and erectors. While most were steel buildings, students also saw some other interesting applications of steel: Dynamic Attractions builds large-scale 4D robotic theatre boxes for theme parks like Universal Studios; another department is working on precision-engineering the world's largest telescope enclosure, working at tolerances in the sub-millimetre scale. The Robson Square Domes, pictured, are part structure and part art; the fabricator and engineer invested considerable time in creating clean, visually attractive connections. Students saw steel in several modes, and as far more than a way to keep buildings upright. Will they build rollercoasters, convention centres, or skyscrapers? These varied examples of engineering in action sparked conversations and opened up new and creative lines of thinking.

The focal point of the trip was the Rainier Square Tower, a 60-storey Seattle skyscraper that will be the first building to use the innovative SpeedCore hybrid steel-concrete shear wall system. The engineering world has its eye on this project, and the Steel Centre got priority access to the fabrication facility, construction site, the engineering firm that designed the system, and the firm's CEO. This level of firsthand access to a global landmark is extremely rare in university education.

First, in Vancouver, the group saw the fabrication in process at Supreme Group's facility. As a founding member of the Steel Centre, Supreme Group is very closely involved in the Steel Centre's research and education programs, and it is exciting to see their involvement in such a high-profile project. The sheer scale of the project is evident upon seeing the pieces at arm's length. Supreme Group developed new methods to efficiently fabricate the project's hundreds of thousands of welds. This creative thinking demonstrates the response to challenges





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that engineers must manage throughout their professional practice.

The following day in Seattle, Magnusson Klemencic Associates (MKA), the worldrenowned engineering firm behind the SpeedCore design, took the Steel Centre backstage to see the construction in progress and hear more about the design challenges in developing the SpeedCore system, providing a great learning opportunity to see this innovative system from start to finish.

The week's events were overwhelmingly positive, and students have brought home a wealth of new ideas and inspiration. Thank you to the many hosts—including Steel Centre members Supreme Group, S-Frame Software, and DIALOG—who gave up work time and weekends to invest in this upcoming generation of structural engineers. Thanks also go to George Third and Son, Dr. Tony Yang at UBC, RJC, Glotman Simpson, Dynamic Attractions, LifeTec, Legacy Engineering, Solid Rock Steel, and Bush, Bohlman and Partners.

Shortly after returning home to Edmonton, the SuperTour was capped with a special visit to the University of Alberta by Ron Klemencic, MKA's chairman and CEO. Ron spent two days exclusively with the Steel Centre to share his expertise, including a keynote presentation for the public at the facility of Steel Centre founding member Supreme Group in Acheson, AB.

Ron's passion for engineering was evident in his many conversations with students. He freely shared his experiences, pulling out actual work samples to help explain a point. Ron showed the importance of combining technical engineering skills and higher-order thinking to work collaboratively and challenge ideas in order to create some of the world's most ambitious projects.



In addition, senior-level guests from engineering consultancies Stantec, RJC, and Steel Centre member DIALOG, joined Ron at a special lunchtime panel session. The group of engineering all-stars spoke to the Steel Centre and other structural engineering students about the challenges and realities of managing a consultancy. This sort of information is not part of the general curriculum, but is immensely useful as students graduate. Many find themselves with questions about the real-world situations they will face in their career development. Ron's depth of knowledge, combined with that of local experts, provided a complete view into the complexities and excitement of managing an engineering consultancy. The visit has sparked a new relationship between MKA and the University of Alberta, which will certainly be of value to students.

Steel Centre students rated the SuperTour very highly, saying that it gave them a new

perspective on how engineers work with others to complete complex projects and has inspired them to consider the many applications of steel construction in their future work. The CISC Steel Centre is committed to discovering and creating unconventional and transformational educational opportunities for students that are not part of any traditional degree program by remaining true to one of its stated core values to "challenge traditional boundaries."



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DESIGN eering building

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member Vixman Construction Ltd. for Pomerleau Construction (Giffels), the Sheridan College Engineering building at the Davis Campus in Brampton is an example of creativity in design and construction using multiple types and finishes of steel. The design and construction collaboration between Vixman, the Pomerleau (Giffels) construction team and architect George Friedman resulted in a unique building incorporating six different steel products and three distinct finishes. In addition to the steel products which comprised a large part of the building's exterior, the structure itself was steel, fabricated by CISC member Telco Steel Works.

The original design proposal necessitated the development of custom panel shapes using 20-gauge type 304 "brushed finish" stainless steel and 18-gauge A606 "weathering steel." Using available stainless coil sizing, Vixman was able to modify the shapes and sizing of the "sawtooth" panel pattern to satisfy the architect's vision while keeping the costs within budget. Test pieces were fabricated to ensure the quality of the fit and finish. Secondary stiffening was incorporated to minimize the surface variations inherent in the steel finish. Similarly, custom-sized flat panels with reveals were designed and fabricated using A606 steel, sourced in standard sizing, again to minimize added cost by avoiding the need for special orders.



The stainless steel panels combined a brushed finish with a custom sawtooth pattern to create an interesting and unique effect in which light, colour and shapes are reflected back to the viewer in a constantly evolving manner. The organic and reflective nature of stainless steel was understood by the design team, and therefore used effectively within the overall design to achieve a different and special result. The adjacent steel wall treatments, both weathering steel and pre-painted steel siding, serve to anchor the structure with a contrasting solid appearance. The variety of steel products used is the focal point of the overall building design, which also includes various glazing and masonry components.

These contrasting exterior steel panel treatments created a unique esthetic but did not solve the requirement for a building envelope solution. This was accomplished using an insulated metal panel system installed directly to the structural steel supports. The insulated panels also served as the support system for the custom exterior panels using a galvanized steel subgirt "rail" system, provided by the IMP manufacturer. In addition to the steel wall products, sloping metal roof areas were completed using a standing seam insulated metal roof panel system, providing a watertight solution and long-term warranty. These insulated panels demonstrate how a steel product not only provides a visually pleasing appearance, but is also useful in dealing with building envelope and structural design considerations. Other areas of the building used elements of conventional pre-painted siding, both vertically and horizontally, as well as pre-painted flashing/fascia/soffit treatments.

The final tally for the project saw Vixman supply and install six steel products (SS panels, A606 panels, insulated metal wall panels, insulated metal roof panels, conventional siding, pre-painted flashings) and three finishes (stainless steel, A606 weathering steel, pre-paint) used in combination to fulfil the architect's and owner's vision for a unique new facility. As a CISC member, Vixman Construction Ltd. is proud to have been involved in the design and construction of this project, showcasing the versatility of steel.

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A BIRD'S EYE VIEW

From 7,160 feet above Whistler Village

By Rob Third, George Third & Son





WALK THE Cloudraker Skybridge and the Raven's Eye Cliff Walk and take in the breathtaking views from Whistler Peak. From the Roundhouse Lodge, walk the Peak Express Traverse to the Peak Express Chair; the suspension bridge is located at the Top of the World Summit. The Cloudraker Skybridge spans 420'-0" from Whistler Peak to the West Ridge, crossing high above Whistler Bowl ski run, 7,160ft above Whistler Village.

The Raven's Eye Cliff Walk consists of a viewing platform with 360° views from Whistler's Peak to the valley below. The cantilevered walkway will extend 12.5m out from the West Ridge, with exhilarating views well above Whistler Bowl.

The Team of Whistler Blackcomb & Vale Resorts, Morrison Hershfield Engineering, Axis Mountain Technical and George Third & Son, signed up for this inspiring endeavour with a steadfast commitment to a successful project.

The main structural head frames for the suspension bridge and the entire viewing platform were erected by special lightweight but mighty KMax Helicopter. The challenges of the lift capacity of the helicopter, mountain top weather concerns, along with safety and crew communication issues, tested our innovative team to the max.

The project timeline started with the desire to have the suspension bridge up before the snow began to fall in October 2017, but the weather changed early that year and we only erected a portion of the work before stopping for the season as the snow and wind took over the mountain top.

The Whistler/Blackcomb Cloudraker Suspension Bridge and Viewing Platform on the peak of the majestic Whistler Ski resort mountain.







Installation halfway, June 2018

"In our 109 years of steel fabricating this was one of our most breathtaking installations ever."

Geordie Third, GM, George Third & Son



The whistler bridge is a 420' clear span that rests on four KISWIRE Hylift K16 - 2" round cables. The cables were strung from just west of the top of the peak chair to the West Ridge. Once the bridge is put up and you get to the end of the bridge, there is a cantilever viewing platform that extends 40' from the cliff face that you can hang out over to look down onto Whistler Village and the valley below, with Blackcomb in the distance.

The steel is all modelled and fabricated in George Third & Son's steel shop. The 1703 bridge parts were fabricated, sent for galvanizing, and brought back for test fitting and final inspection, before shipping to the site. Most pieces were trucked to the top of the mountain, with some of the larger pieces brought up and installed by helicopter. The smaller pieces were assembled at the top of the mountain and put onto the cables one basket assembly at a time, and slid across the cables until forming the suspension bridge that spanned the full 420'.

Assembling the bridge baskets on the mountain top started June 10, 2018, with Mother Nature once again bringing snow to the top of Whistler. It looks like winter in the pictures, but it was the start of summer.

When it came time for the viewing platform installation, the main challenge was to bring in and install all the parts using a specialized Kaman K-MAX helicopter. It is a helicopter with intermeshing rotors, optimized for external cargo load operations, and is able to lift a payload of over 6,000 pounds, which is more than the helicopter's empty weight. We only had a

"It's been fantastic working with GTS!"

Ryan Foster, Axis Mountain Technical





short window to use it. The 40' long beams, which weighed 5,000 lbs each, forced the pilot to restrict his fuel load to allow for that much lifting power, so he had to re-fuel multiple times to make sure the payload wasn't too heavy. Things went very smoothly and the cantilever install started at 9 a.m. and was finished by 3 p.m.

We don't usually trial assemble our parts in the shop because we are confident everything fits, all our details are done with 3D Models, steel is cut with Robotic CNC machines, and the craftsmanship at George Third & Son put things together correctly. But we wanted to be doubly sure, so we actually assembled the viewing platform completely at our plant. Making sure the end of the cantilevered piece fit exactly was imperative to reduce the risks for the install team of Axis Mountain Technical, standing out at the end of the bridge receiving the 5,000lb. end frame on the end of a strap carried by a helicopter.

There were some challenges, and the first attempt to attach this final part was not successful and we needed to adjust some of the steel's positioning on the anchor bolts to make it fit. So we needed to put the piece down once to do Ironworkers. SAFETY. QUALITY. PRODUCTIVITY.



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some tweaking in and out, then come back with the chopper, and made it on the second try.

The challenges of working with everyone cantilevered out over the edge, tied off so they don't fall to their peril, while working beneath a live helicopter, demands everyone know what to do in advance of the steel arriving. It is almost impossible to hear each other, so unique hand signals were needed. It is quite dangerous work; if the helicopter pilot is in danger, and ever lets go of the load, which he has the ability to do, it can be catastrophic.

The toughness and durability of the galvanizing enabled us to manhandle the steel in this remote location unlike any other protective coating.

The suspension bridge was installed in the summer, and still we dealt with snow and howling winds in mid-June. After erecting the head frame supports and tying the cables to the rock faces, the suspension bridge baskets were erected from one end and rolled across to the other end by a custom-built trolley system.

PROJECT NUMBERS

186,000 POUNDS OF STEEL

HEAVIEST HELICOPTER LIFT: 5,300 POUNDS

1,703 PIECES TOTAL

PROJECT DURATION: 7 MONTHS

"It has been a pleasure for us working with everyone at GTS. We are extremely pleased with how both structures turned out."

Rob McSkimming, Project Manager, Vail Resorts

The finished product is a superb tourist experience thousands of feet above the resort that will last eternally, made of galvanized steel. Galvanizing was the obvious choice for this project given the life cycle, durability, and economics of Hot Dip Galvanizing.

The Third family has two residences in Whistler and have been skiing the mountain for over 40 years, and we are very proud to be involved in this project that has changed the landscape forever for all to enjoy.





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STRUCTURAL STEEL

Helping to realize the potential of prefabricated prefinished m

By Tom Greenough and Matthew Smith, Entuitive

INTRODUCTION

Prefabricated prefinished volumetric construction (PPVC), sometimes referred to simply as modular construction, is a process whereby buildings are planned and designed to allow for discretization and standardization of 3D volumetric structural units that allow for efficient off-site manufacture and rapid on-site assembly. The fabrication and manufacture process results in a partially to fully fitted out module built under controlled conditions. Prefabrication in the construction industry is not new: curtain wall manufacturers have realized the benefits of off-site construction for many years. Repeatable, labour-intensive components of larger buildings, such as washrooms, have also enjoyed the benefits of off-site construction¹. These non-structural modular units are then placed within a site-built structure. Purpose-designed and built pre-engineered buildings have also been around for centuries. The total prefabrication of large contemporary buildings is seeing increased attention by clients as they look for opportunities to reduce project schedules and achieve a greater degree of cost certainty.

The ability for the construction industry to respond to this opportunity is made possible by advances in Building Information Modelling (BIM), investments in prefabrication facilities, and modern building materials and methods. The benefits of this approach to building construction are reduced construction time (Figure 1), reduced cost, consistent quality, increased worker safety, and a cleaner, quieter construction site. The ability to manufacture the modules concurrently with on-site foundation and podium work is one of



FIGURE 1: Possible schedule savings with modular construction. Adapted from *Introduction to Commercial Modular Construction* by Modular Building Institute.

the huge advantages of modular construction which allows for significant time savings. The construction industry is often regarded as ripe for innovation², with PPVC being one such opportunity that can improve productivity^{3,4} while keeping a workforce increasingly short of skilled tradespersons engaged.

PREFABRICATED MODULAR CONSTRUCTION

The design and construction of modular buildings comes with unique challenges compared to site-built construction that all project stakeholders must be aware of for the project to be a success. These peculiarities are outlined below.

Project Team Organization

The fragmentation of the design and construction process has limited the effectiveness of collaboration and often resulted in an adversarial construction culture much to the disadvantage of all stakeholders. Furthermore, buildings are often conceived as unique projects every time and employ temporary teams, unlike the manufacture of consumer goods in other production industries. The advantages of a consistent team have been realized by some design-build entities who continually engage with the same consultants and subcontractors. By controlling the workflow in much the same way, PPVC manufacturers can keep a consistent team. This requires early engagement of a modular manufacturer and this aspect is often regarded as essential to project success. Once engaged, the modular manufacturers may manufacture for a general contractor or contract directly with owners to provide modular solutions and fulfill the role of general contractor. Modular manufacturers may also have internal architects and engineers that can assist throughout the design and manufacture process.

Design Considerations

The decision to go modular needs to be made early on (schematic design or earlier) to ensure the building is developed with

odular construction

modular preferences and efficiencies in mind, rather than trying to fit a modular system to a conventional building after the fact. The design must be conceived with modular construction in mind from the outset and must strike a balance between design intent and the production process. An understanding and appreciation for the production process is crucial to discretizing a building into modules and ensuring the design of the modules is efficient from a fabrication perspective, while keeping in mind that standardization is key to increasing PPVC productivity. As well, the architect must be mindful of the modular layout when determining the space planning of the building.

Cellular-type buildings such as condo/ apartments, hotels, and student residences are well suited for PPVC. There are also some trade-offs that need to be considered in the overall building design including:

- Increase to structural floor assembly thickness and therefore floor-to-floor heights
- Double wall construction resulting in thicker wall assemblies (may improve acoustics)
- Spans and configurations may be somewhat restricted
- Flexibility and adaptability of structure through future renovations becomes more difficult

Therefore, it is not uncommon for projects to have a hybrid solution such as a portion of the building that is modular and a portion that is site-built due to programmatic requirements that require longer spans, large column-free areas, or areas that are difficult to pre-assemble in the factory. The actual size of modular units is typically dictated by transportation constraints, on the order of 4,500 mm (15') wide, 18,000 mm (60') long, and 3,600 mm (12') tall, although dimensions will vary depending on the project location and the route from the factory. In addition, the maximum desirable distance for transportation of modules is 400 to 600 kilometres (250 to 400 miles).

Furthermore, a prefabricated modular building does not need to look and feel "boxy" or completely rectilinear when complete. A competent and experienced design team can create expressive architecture and varied interior spaces while achieving the benefits offered in prefabricated modular construction.

Temporary Conditions

All buildings are designed for their final condition. However, PPVC buildings must be designed not only for their final condition but also for forces that each module must withstand during transportation and hoisting. The magnitude and nature of these forces may differ depending on the means and methods used, including pick points and dunnage locations. It is essential to coordinate these temporary conditions with the manufacturer, transport company and erector to ensure modules are designed with adequate strength and stiffness for all conditions they will experience.

Materials

Modules can be constructed from a variety of different materials including wood framing (both dimensional and engineered), coldformed steel framing, hot rolled steel, concrete or a hybrid combination of materials. Module manufacturers tend to focus on a particular type of construction material to maximize production efficiency. The choice of material by the stakeholders should consider the specific project requirements including structural force/loading demands and the budget.

Structural steel is an ideal choice for PPVC as it is already to a certain extent prefabricated in the shop and assembled/ erected on site. Furthermore, the use of structural steel chassis in PPVC will open or at least expand market opportunities for structural steel as an alternative to cast-in place reinforced concrete for high-rise condominiums and hollow core slabs supported on masonry for low-rise apartment and assisted living facilities.

2. https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/imagining-constructions-digital-future 3. https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-aproductivity-revolution

4. https://www.modular.org/marketing/documents/Whitepaper_ImprovingConstructionEfficiency.pdf

^{1.} https://www.pcl.com//Meet-the-PCL-Family/Locations/Canada/Toronto/Publications/PCL-Agile.pdf

FEATURE

Tolerances

Crucial to the success of any PPVC building are extremely tight tolerances in the modules so that erection is quick and accurate, making structural steel an ideal material choice due to its dimensional stability and the precision fabricators can achieve. The horizontal and vertical interconnection of modules in particular pose a challenge as they need to not only have tight tolerances, but they must also transfer lateral and gravity forces between modules. Fabricators can solve this problem through custom connections or steel castings.

One example of a casting that the authors have experience with is the propriety Z Modular's VectorBloc system, as seen in Figure 2a, where a cast node not only forms a robust connection point for perimeter beams and columns but also allows modules to be fastened together efficiently. The configuration in Figure 2b is just one possible VectorBloc module-to-module connection; many other configurations are possible with different types of VectorBlocs which gives designers increased freedom in developing their PPVC building.

Approvals Process

PPVC generally requires an approvals process that is different from site-built construction projects. The challenge for PPVC from an approval's perspective is that modules may be fabricated in a different jurisdiction than where they are ultimately erected. In general, the requirement is that the modules be designed and constructed to comply with codes and regulations in force at the installation location. However, it can often be difficult to determine whether a module complies with these requirements since many wall, roof and floor assemblies are closed-in when the module arrives on site, hindering inspection. To address this problem, many U.S. states require modular or factory-built

"A prefabricated modular building does not need to look and feel 'boxy' or completely rectilinear when complete. A competent and experienced design team can create expressive architecture and varied interior spaces while achieving the benefits offered in prefabricated modular construction." at the manufacturing plant, the extent and cost of which can vary from state to state. In Canada, CSA A277, *Procedure for Factory Certification of Buildings*, relies on an independent certification agency for the assurances to the authorities at the final site that the manufactured elements comply with the code. Transportation requirements are also regulated at the state/province level, each of which have differing codes, permitting, lead cars requirements, and associated fee structures.

As mentioned above, modular buildings must still meet local building codes. From a fire safety standpoint this typically requires floors and walls to have fire-resistance ratings. What is unique about modular buildings is that the structure from adjacent modules can fall within the assembly. In floors, for example, it is not uncommon for the roof structure of the lower module to support the ceiling while the floor of the upper module supports all finishes and floor loads. There is currently a dearth of available UL-tested assemblies that have dual structures like this, which means designers have few options and must either undertake an Engineering Judgement on an existing assembly or perform full-scale testing on their own modular assembly. Additionally, many jurisdictions put a limit on the height and area of combustible construction, making structural steel the only feasible non-combustible structural material for large modular buildings without going through the alternative solutions process required for tall timber construction.





FIGURE 2B: Diagrammatic of Z Modular VectorBloc modular construction system. Image courtesy of Z modular.

building components to be reviewed and certified at the state level by a state-certified third-party agency. The responsible state department may also have further specific requirements that regulate the design, approval and inspection of the building

CTURES & INNOVATIONS

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FIGURE 3: Model and analytical view of chassis framing for individual module.

Lastly, not all building code jurisdictions are as open to off-site construction. It is best to consult with the Authority Having Jurisdiction (AHJ) early in the process to understand the requirements and necessary approval timeframes.

Contract Document and Structural Analysis

By using structural steel as the underlying structure for PPVC buildings, designers can take advantage of wellestablished workflows while finding new opportunities specific to PPVC buildings.

For example, to define individual modular chassis, the authors have developed scripts in Dynamo, a visual programming plugin for Autodesk's Revit, to define all parameters, including dimensions, member sizes, and framing configuration. Crucially, this model also contains an underlying analytical model that captures the structural steel member sizes, work points, and end releases as shown in Figure 3.

This is done for each type of module within the building, including habitable units, stairs,

and elevators. The individual Revit files are then assembled into a master coordination model using an architectural model to guide the placement of modules. An example of an assembled Revit model for a modular building is shown in Figure 4.

The BIM is then linked to conventional structural steel analytical programs to facilitate the analysis and design of the structure. In the above example, the analytical representation of each individual module is maintained in the assembled model, and appropriate horizontal and vertical linkages between all modules are automated. Engineers then assign loads and load combinations to the analytical model and go about completing the design like one that would be site-built. However, the vast number of structural elements in a typical modular building makes data management a challenge. In response, the authors have also developed novel scripts using Grasshopper, a visual programming plugin for Rhinoceros 3D, to sort through all the data, present it in meaningful ways, and identify critical values for design purposes.



FIGURE 4: Assembled chassis modules into master model.

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CASE STUDIES

The following two projects demonstrate how the advantages of modular construction outlined herein have been realized in a residential and commercial building application. Each project had unique challenges that were overcome using intelligent modular solutions, and by leveraging the strengths of structural steel.

Case Study 1: Cheatham Street Flats

Cheatham Street Flats, located in San Marcos, Texas, will be a 143-unit, 234-bed student housing mixed-use development. This innovative project features site-built foundations and a reinforced concrete parking structure that will support four levels of prefabricated modular construction using the Z Modular system. The building comprises habitable modules, non-habitable modules for vertical access and services, and planar hallway modules. A rendering of the building is shown in Figure 5.

Amenity and public space at the main entrance requires a transfer structure compatible with the unique modular system. Structural steel proved ideal for this transfer structure, as custom connections with a high degree of adjustability allowed the modules to be supported with tight tolerances. Web openings in the wide flange shapes will be used to run services while maintaining a high ceiling. The model used for structural analysis and design is shown in Figure 6, which was important not only for the design of the modules but also for assessing the impact relative deflections in the steel and concrete support structures had on the modules.

Cheatham Street Flats is currently being fabricated at a rate of up to four habitable modules a day while the site-built portions of the building are under construction. Modules in the fabrication facility are shown in Figure 7. Residents are expected to move in August 2019.



FIGURE 5: Cheatham Street Flats. Rendering courtesy of Forge Craft Architecture + Design.







FIGURE 7: Modules at various stages of completion. Image courtesy of Z Modular.

Case Study 2: Reliance Metalcenter

Reliance Metalcenter located in San Antonio, Texas, is constructing a new administrative office adjacent to its existing facility. The modular office building will be one storey with a floor area of 760 m² (8,150 ft²). The office will comprise 22 modules with structural steel frames using the Z Modular system that are supported on site-built reinforced concrete foundations.

Modular clerestories above the roof are attached on-site and, by spanning end-to-end with integrated trusses, enable an open-plan office with an abundance of natural light. Trellises and other architectural elements are also prefabricated and attached on-site to achieve the architectural intent for the building while respecting maximum module dimensions for efficient shipping.



FIGURE 8: BIM for Reliance Metalcenter

CONCLUSION

Prefabricated prefinished volumetric construction is not a solution for every building project, but represents an opportunity for the construction industry to further innovate and shorten construction schedules, achieve a greater degree of cost certainty, improve building quality, reduce building waste, and increase worker safety and comfort. However, this form of construction has specific challenges that require consideration at the very beginning of a project by a competent and experienced design team. A collaborative approach is required to ensure all architectural, engineering, and manufacturing design decisions are holistic and work toward the goal of a successful, high-performance modular building.



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CSA S16 Design of Steel Structures	CSA S16-14	CSA S16-19	Sep. 2019
CISC Commentary on CSA S16 (Part 2 of CISC Handbook of Steel Construction)	CISC Handbook 11th Edition ¹ 3rd Printing ²	CISC Handbook 12th Edition	late 2020
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CSA S6 Canadian Highway Bridge Design Code	CSA S6-14	CSA S6-19	Sep. 2019
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CSA G40.20/G40.21 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel	G40.20-13 G40.21-13	ТВА	
CSA W59 Welded Steel Construction (Metal Arc Welding)	CSA W59-18	CSA W59-23	Sep. 2023
CSA W47.1 Certification of Companies for Fusion Welding of Steel	CSA W47.1-09 (R2014)	CSA W47.1-19	Summer 2019
CSA S136 North American Specification for the Design of Cold-Formed Steel Structural Members	CSA S136-16	Supplement No. 1	Spring 2019
CSA S136.1 Commentary on CSA S136	CSA S136.1-16	Supplement No. 1	Spring 2019

¹CISC Handbook of Steel Construction - 11th Edition includes CSA S16-14, its Commentary, CISC Code of Standard Practice - 8th Edition (new), and design and detailing aids in accordance with CSA S16-14

²3rd Printing of Handbook has been updated to reflect changes introduced in CSA S16-14 Update No. 1 released in Dec. 2016

³Adopted in S16-14 by reference

TBA = to be advised

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