# the STEEL centre

# challenge traditional boundaries.

# 2019 ANNUAL REPORT

Dr. Robert Driver
Director

UNIVERSITY OF ALBERTA

cisc icca

**CISC Centre for Steel Structures Education and Research**
University of Alberta
Faculty of Engineering
Department of Civil and Environmental Engineering


we do
cool stuff
for the
real world.


# contents

# from the director

2019 at the Steel Centre saw a consolidation of our momentum and vision, most apparent in being awarded the designation of "Academic Centre" by the University of Alberta, but equally expressed in our growing student researcher body, expansion of the Steel Centre's mentorship efforts, and ongoing research contributing new knowledge to industry and influencing codes and standards across the continent. We enter the new decade with enthusiasm to develop these programs further.

Students are the core of the Steel Centre vision, and we continue to seek out innovative and boundary-challenging methods to enhance their education and training. SCORE, the student-run engineering consultancy, formed a new level of partnership with industry member DIALOG to design a portion of an active project. These genuine partnerships give rise to authentic mentorship experiences that no 'industry mixer' can provide. 2019 marked a visible effort to observe and improve how mentorship happens at the Steel Centre; the coming year will take this as our focus for continually building a student-centred education and research hub.

Industry partnerships drive the Steel Centre, both in our research programmes and in educating a generation of young engineers. Active involvement from industry in all research projects builds networks of knowledge, trust, and sets the stage for new ideas to emerge. Our interdisciplinary partners take unique perspectives on situations and lead us to better and more relevant paths.

The Steel Centre is propelled forward by our best year yet – now, onward to another year of excitement, progress, and new ideas.

Robert G. Driver
Director

# vision

The Steel Centre **imagines and transforms** the future of structural steel design, fabrication, and construction.

# mission

We are an i**ndustry-driven, student-centred** education and research network dedicated to **continually advancing the steel industry**, engaging in interdisciplinary collaborative research, providing **innovative education opportunities**, and developing leaders of the future.

# values

We **challenge traditional boundaries.**

We are a **collaborative community** with uncompromised integrity.

**Excellence** is in our DNA.

We do **cool stuff for the real world!**

# people

**Dr. Robert Driver, P. Eng.**
Supreme Steel Professor
Steel Centre Director
*Steel Structures*

**Dr. Ali Imanpour, P. Eng.**
Assistant Professor
*Steel Structures*

**Dr. Roger Cheng, P. Eng.**
Professor, C.W. Carry Chair of Steel Structures
*Steel Structures*

**Dr. Leijun Li, P. Eng.**
Professor
*Welding Metallurgy*

**Dr. Doug Tomlinson**
Assistant Professor
*Steel/Concrete Composite Systems*

**Dr. Yong Li**
Assistant Professor
*Reliability & Advanced Analysis*

**Dr. Yasaman Balazadeh Minouei**
Post-doctoral Fellow
*Steel Structures*

**Dr. Bo Dowswell, P. E.**
Consulting Research Engineer
*Steel Structures*

**Matt Jeppesen**
Programs Administrator

**AJ Darras**
Research Assistant

**Greg Miller**
Structural Engineering Technician

**Cam West**
Structural Engineering Technician

# current students

**Abolfazl Ashrafi (Ph.D.)**
Supervisor: Dr. Imanpour
*Seismic Response Evaluation and Design of Steel Multi-tiered Eccentrically Braced Frames*

**Vahab Esmaeli (Ph.D.)**
Supervisors: Dr. Imanpour, Dr. Driver
*Structural Stability and Design of Steel Cantilever Systems*

**Pablo Cano (Ph.D.)**
Supervisor: Dr. Imanpour
*Test-based Design Methods for Steel Multi-tiered Concentrically Braced Frames*

**Safa Masajedian (Ph.D.)**
Supervisors: Dr. Driver, Dr, Imanpour
*Progressive Collapse Resistance of Composite Steel Frame Structures*

**Ahmed Mowafy (Ph.D.)**
Supervisors: Dr. Imanpour, Dr. Chui
*Advanced Hybrid Steel–Timber System for Seismic Applications*

**Mahdi Mokhtari (Ph.D.)**
Supervisor: Dr. Imanpour
*Development of a resilient steel modular moment-resisting system for seismic and wind applications*

**Brittney Lopushinsky (M.Sc.)**
Supervisors: Dr. Tomlinson, Dr. Driver
*Rehabilitation of Deficient Concrete Columns with Steel Confinement Collars*

**Eshagh (Isaac) Derakhshan Houreh (M.Sc.)**
Supervisor: Dr. Imanpour
*Development of Simplified Seismic Design Guidelines for Steel Concentrically Braced Frames in Regions of Low and Moderate Seismicity*

**Akram Zain (M.Sc.)**
Supervisors: Dr. Imanpour, Dr. Driver
*Performance and Design of Prefabricated Steel Braced Frames for Industrial Buildings*

**Ian Chin (M.Sc.)**
Supervisors: Dr. Driver, Dr. Tomlinson
*Standardization of Embedded Plates for Steel/Reinforced Concrete Connections*

**Sheldon Twizell (M.Sc.)**
Supervisors: Dr. Imanpour, Dr. Driver
*Assessing the in-elastic lateral torsional buckling performance of Canadian design standards for welded girders*

**Abrar Islam (M.Sc.)**
Supervisor: Dr. Imanpour
*Development of Enhanced Design Methods for Deep Wide-Flange Columns in Steel Moment Resisting Frames under Earthquake Loading*

**Fardad Mokhtari (M.Sc.)**
Supervisor: Dr. Imanpour
*Application of the Hybrid Simulation Technique to Evaluate the Seismic Response of EBF Links*

**Tony Yu (M.Sc.)**
Supervisor: Dr. Imanpour
*Predictive Fracture Model for Hollow Structural Sections subjected to Earthquake Loading*

**Vincent Malazo (M.Sc.)**
Supervisors: Dr. Imanpour, Dr. Driver
*Design Method for Steel Gerber Systems*

**Caine Smithaniuk (M.Sc.)**
Supervisor: Dr. Tomlinson, Dr. Driver
*Improving the Design and Constructibility of Steel/Reinforced Concrete Connections*

**Harsh Patel (M.Eng.)**
Supervisor: Dr. Imanpour
*Quantify contribution of large P-Delta effect to design forces of columns in steel MRF*

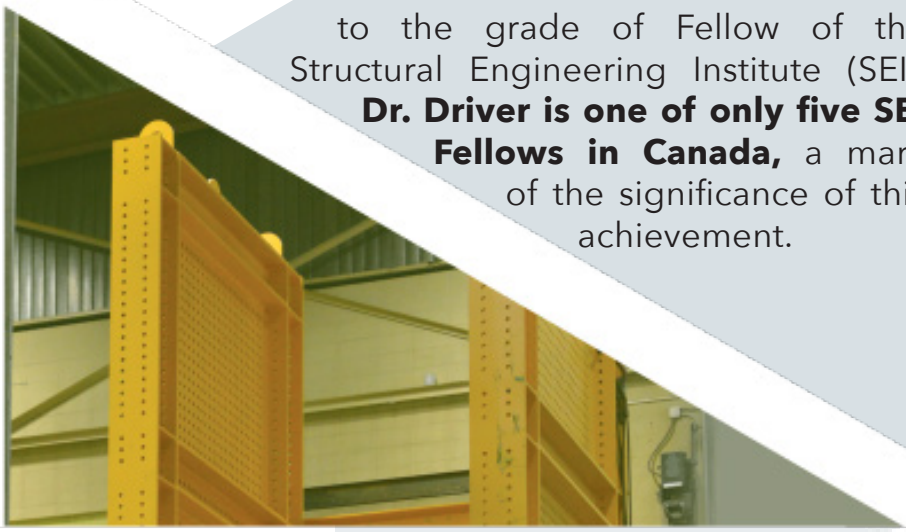
**Lomude Mori (M.Eng.)**
Supervisor: Dr. Driver
*Stability of Extended Shear Tabs*

**Adam Coleman (M.Eng.)**
Supervisor: Dr. Driver
*Stability of Extended Shear Tabs*

the STEEL centre

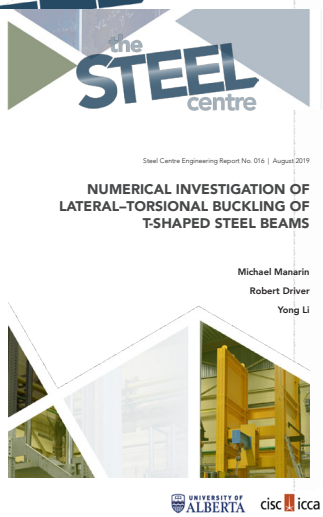
# 2019 highlights

Steel Centre Director Dr. Robert Driver was elevated to the grade of Fellow of the Structural Engineering Institute (SEI). **Dr. Driver is one of only five SEI Fellows in Canada,** a mark of the significance of this achievement.



UNIVERSITY OF ALBERTA

The Steel Centre was awarded **Academic Centre status** by the University's Academic Planning Committee, in recognition of having attained a superior level of development, with solid leadership, financial planning, and a purpose that supports the University's mission. The designation is not easily attained; **the Steel Centre is one of only three Academic Centres in the entire Faculty of Engineering.**




The Steel Centre's research outputs, known as **Steel Centre Engineering Reports (SCERs)**, are now available at steelcentre.ca/reports. These publications provide the latest in research findings from the Steel Centre with full discussion of methodologies and results.

AJ Darras is the newest member of the growing Steel Centre team. As a **full-time Steel Centre research assistant,** he will provide research support across projects while helping to advance computational design research, an area of particular expertise for AJ. He holds an M.Eng. in Structural Engineering and most recently worked with Steel Centre member DIALOG. Welcome AJ!


# 2019 graduates

## Dimple Ji, M.Sc.

**Lateral-Torsional Buckling in Wide-Flange Welded Girders**

Dr. Driver, Dr. Imanpour

Dimple conducted North America's largest lateral-torsional buckling tests as part of her research into this complex behaviour. As a result, the national standard on the design of steel structures will undergo reevaluation in this area in the next code cycle. Dimple went on to begin work at Steel Centre collaborator MKA in Seattle.

## Daniel Unsworth, M.Sc.

**Residual Stresses in Welded Girders**

Dr. Driver, Dr. Leijun Li

Daniel's work on residual stress distributions significantly furthered our understanding of residual stresses in modern girders. His work showed that previous numerical research by others has overestimated the severity of these stresses, leading to questionable conclusions. Daniel has taken a year to travel in Asia before returning to begin his career.

# Michael Manarin, M.Sc.

**Lateral-Torsional Buckling of Singly Symmetric Welded Three Plate Girders**

Dr. Driver, Dr. Yong Li

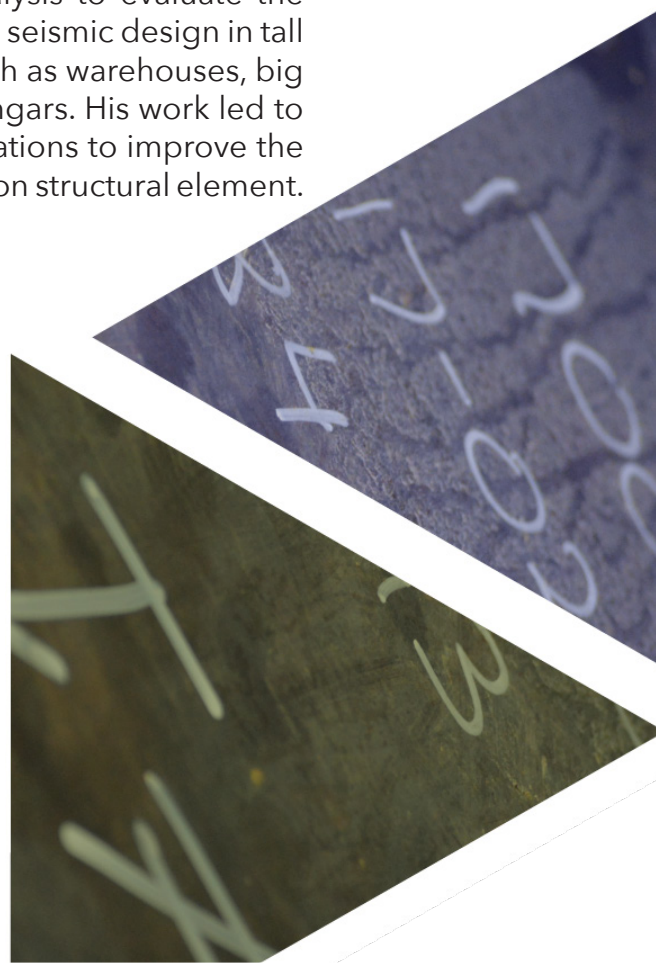
Welded three plate girders are commonly used in bridge construction. Michael conducted in-depth analysis on singly-symmetric sections to build upon the conclusions of doubly-symmetric tests currently being conducted at the University of Alberta.

# Pablo Cano, M.Sc.

**Evaluation of Seismic Design Methods for Steel Multi-Tiered Concentrically Braced Frames**

Dr. Imanpour

Pablo used numerical analysis to evaluate the current code provisions for seismic design in tall single-storey buildings such as warehouses, big box stores, and airport hangars. His work led to code change recommendations to improve the performance of this common structural element.



# S.C.O.R.E.
## Steel Centre OutReach Engineering

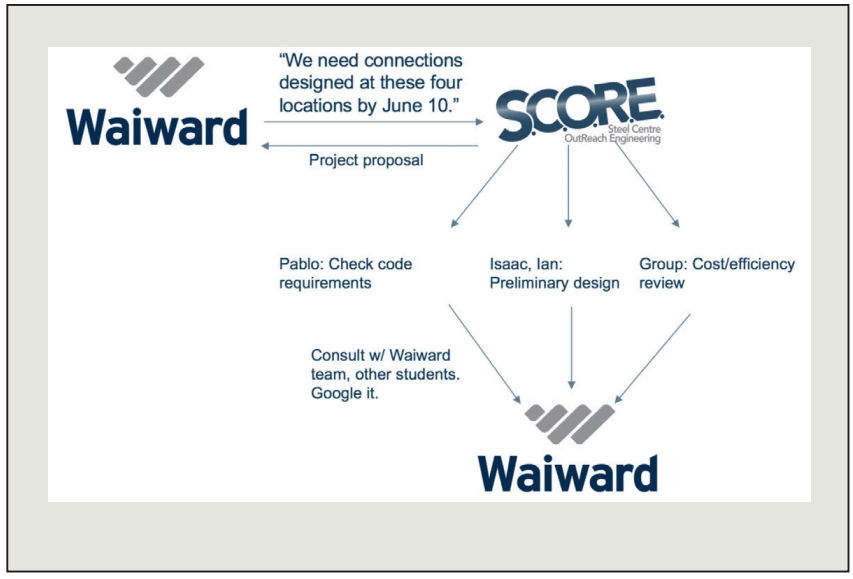
**A new student-led engineering consultancy will take on actual projects from our industry partners to teach real-world skills and build genuine mentorship.**

Steel Centre OutReach Engineering (SCORE) is a student-run engineering consultancy devoted to innovative solutions to real-world problems in the field of structural engineering. The primary goal is to provide opportunities for students to develop technical and interpersonal skills while assisting the Steel Centre's industry partners ("clients") to obtain solutions for challenging problems without being constrained by conventional practices. By participating in SCORE projects, students gain from the years of accumulated insight at Steel Centre member organizations. Both industry professionals and students enjoy the benefits of forming new relationships built on authentic mentorship experiences.

SCORE works exclusively with the Steel Centre's member organizations, adding to the already significant portfolio of membership benefits. SCORE offers M.Sc. and Ph.D. students who have the technical fundamentals and fresh perspectives to solve difficult problems using innovative and creative solutions. After this initial startup period, students will evaluate the potential for undergraduates to join as well.

Once a proposal request is submitted to SCORE, the students of the Executive Council are responsible for communicating with the client and coordinating the preparation of a proposal and budget. The Executive Council presents the project to the SCORE team to determine capacity, interest, and availability. If the project is approved to move forward, the Executive Council submits a proposal in consultation with the industry partner.

Once the proposal is accepted, a contract is signed by the client, a the Executive Council, and the Project Lead, a rotating position that will give all students project management experience. Each member of the SCORE team commits their time for the duration of the project, just as they do for any other extracurricular activity.




SCORE uses a "mini" integrated project delivery (IPD) model, whereby co-location and access to the people, technology and resources of clients encourage collaboration and professional development. For

organizations based in Edmonton, the team travels to the client's office one day per week for the duration of the project. For companies that are not based in Edmonton or cannot offer office space to the project team, SCORE will hold online meetings. Once the project is completed, there is a close-out meeting in which SCORE presents their work and deliverables to the client and to other students. At this time, the client has an opportunity to provide constructive feedback to further enhance the learning potential of the experience.

SCORE does not actually bill clients, but rather request donations to a worthy charity selected in discussion with the client. The donation shall be determined as a percentage of the fee of a junior engineer. Students prepare a real-cost quotation within the proposal to help gain experience in estimating and working to meet targets—as well as mitigating expenses when projects overrun.

SCORE's first projects worked with Collins Steel and CISC. Students spent time on-site at Collins Steel and gained a fresh perspective on the day-to-day rhythm of engineering practice. Clients and consultants were both pleased with the outcome, and the successful first projects have increased the team's confidence to take on new and more complex projects.

Recently, SCORE began working with DIALOG on an initially confidential proposal, adding another layer of real-world experience as they managed information security, privacy, and nondisclosure agreements.

The Steel Centre is immensely proud of our students for their efforts and energy in launching this new program. A special thank you to our member organizations, without whom SCORE and other innovations like it would be impossible to imagine or implement.

Steel Centre member DIALOG and student-run consultancy SCORE worked together to create and propose a partnership at the RFP stage of the upcoming renovation for the IF Morrison Structural Engineering Laboratory at the U of A.


DIALOG's proposal was successful, opening the door to a fantastic opportunity for Steel Centre graduate students to work on a live project in tandem with professional engineers.

Now SCORE will meet with DIALOG's team to define their scope of work. SCORE will put their engineering knowledge to work, with DIALOG reviewing their designs. It will no doubt be a learning experience, especially as the team is exposed to the realities of shifting project schedules and conditions. We all look forward to seeing this partnership develop in 2020.

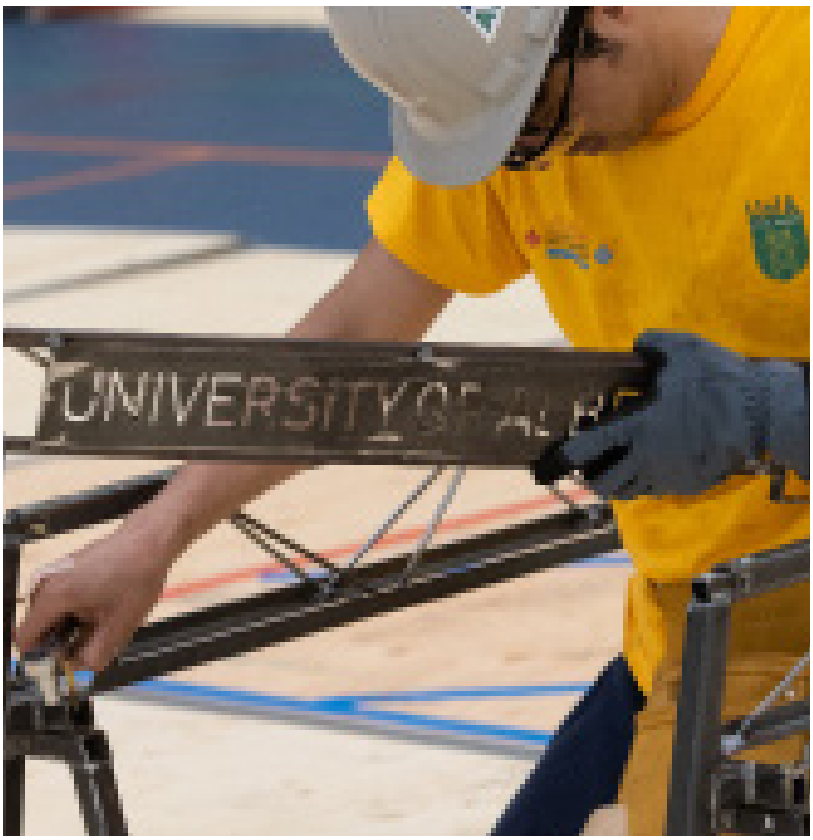
# Steel Centre leads first-ever U of A team at the Canadian National Steel Bridge Competition

In May 2019, the Steel Centre led the U of A's first team in the Canadian National Steel Bridge Competition (CNSBC) in Montréal. Students worked together from across the University to create a scale version of a modular bridge design that can be rapidly deployed and installed. The team then competed against other Canadian teams to assemble the bridge in the shortest time possible, according to a set of rules that reflect real-life technical and logistical challenges. The Steel Centre's students naturally rose into strong leadership roles, as technical experts and also as leaders.

Steel Centre students were front and centre at the recent competition in Montréal. They quickly formed a team late Fall and prepared design concepts, gained sponsorship for materials and fabrication, and successfully built a competition bridge. The team, composed of students from across the University, assembled the bridge

as quickly as possible while obeying strict rules designed to simulate the constraints of real-world bridge engineering.

This first year provided numerous learning opportunities to fuel next year's team, in the competition and in their future practice. Actually designing, fabricating, and building a structure provides unique experiences and enhances everyone's understanding of the process. Congratulations and good luck for next year!




Left: Abolfazl Ashrafi (Ph.D.) assembles the bridge at competition; Right: The 2019 CNSBC team.

# hands-on education for undergrads

The Steel Squad learned from Steel Centre member S-Frame and toured facilities around Edmonton as part of the growing effort to enhance education with hands-on experience.

The Steel Squad began in Fall 2017 as a competitive-entry group to provide unique opportunities for undergraduate students interested in structural steel. Five students from any program year are selected annually, and remain in the Squad for the duration of their academic careers. The Steel Squad offers students real-world experiences such as shop tours, jobsite tours, job shadowing and mentorship, and hands-on demos. Enthusiasm is extremely high from both industry and students to explore how to further expand the reach and impact of this new program. In 2019, the first *Steel Centre Certified* designation was awarded, a certificate to recognize the additional knowledge that Steel Squad membership brings. In the coming year, the program will engage more Steel Centre member organizations to create early links between future engineers and industry experts.

# research

At the Steel Centre, every student, including undergraduates, is involved in a research project. This hands-on experience coupled with outstanding education quality produces students that have a deeper, more natural understanding of steel construction. Steel Centre students work closely with partners from Alberta's leading companies to identify and solve real problems faced by the steel construction industry.

Steel structures research at the University of Alberta typically involves both large-scale testing in the I.F. Morrison Structural Engineering Laboratory, as well as computer modelling including high-fidelity applications. Steel structures research carried out at the University of Alberta has been influential in the development of design codes and standards world-wide.

Current research at the Steel Centre covers a range of topics, but one theme is especially prominent. One significant area of work is investigating lateral-torsional buckling (LTB) and concerns that the current design equations for welded steel girders may be unconservative. Students in the LTB group are measuring the effects of residual stress on LTB capacity. Last year, the group conducted the country's largest full-scale bridge girder test, providing up-to-date data that takes into account the significant changes in modern fabrication techniques since the seminal LTB work done in the 1970s. Now, this research theme continues with investigations into LTB capacity in Gerber systems.

See the list on the following page for other significant areas of research at the Steel Centre.

# recent research topics

## structural stability

Structural Stability and Design of Steel Cantilever Systems

Assessing the inelastic lateral torsional buckling performance of Canadian design standards for welded girders

Design Method for Steel Gerber Systems

Quantify Contribution of Large P-Delta Effect to Design Forces of Columns in Steel MRFs

Stability of Extended Shear Tabs

Progressive Collapse Resistance of Composite Steel Frame Structures

## prefabricated structures

Performance and Design of Prefabricated Steel Braced Frames for Industrial Buildings

Development of a resilient steel modular moment-resisting system for seismic and wind applications

## seismic design guidelines

Seismic Response Evaluation and Design of Steel Multi-tiered Eccentrically Braced Frames

Test-based Design Methods for Steel Multi-tiered Concentrically Braced Frames

Advanced Hybrid Steel–Timber System for Seismic Applications

Development of Enhanced Design Methods for Deep Wide-Flange Columns in Steel Moment Resisting Frames under Earthquake Loading

Development of Simplified Seismic Design Guidelines for Steel Concentrically Braced Frames in Regions of Low and Moderate Seismicity

Application of the Hybrid Simulation Technique to Evaluate the Seismic Response of EBF Links

Predictive Fracture Model for Hollow Structural Sections subjected to Earthquake Loading

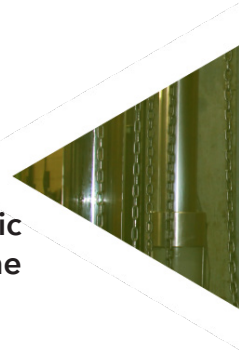
## construction & rehabilitation

Rehabilitation of Deficient Concrete Columns with Steel Confinement Collars

Standardization of Embedded Plates for Steel/ Reinforced Concrete Connections

Improving the Design and Constructibility of Steel/Reinforced Concrete Connections

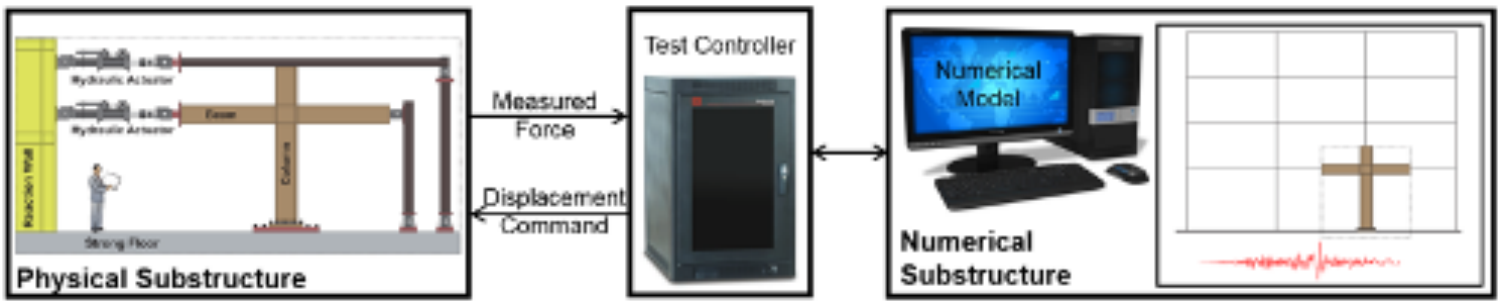
# unique hybrid testing system coming to the U of A



**An advanced hydraulic actuator system can simulate dynamic loads such as earthquakes, bringing new capabilities to the University of Alberta's structural steel research team.**

Novel testing techniques in structural and earthquake engineering result in better understanding of the behaviour of structural systems and higher levels of safety for infrastructure in Canada. Hybrid testing is a next-generation simulation method that combines the accuracy and reliability of physical testing with the flexibility and high computational power provided by computer models. A hybrid system, as the name suggests, incorporates a physical test specimen in the laboratory and a computer-based model that generates high-fidelity response simulations in real time as the test is in progress. Hybrid testing offers a versatile and economically viable structural testing technique to study the response of a wide range of structural components, connections, subassemblies, and systems by only testing a part of the structure and performing numerical simulation of the rest of the structure in real time. By acquiring this system, the Steel Centre's research team is able to make significant fundamental and applied contributions in three key research areas including response evaluation and validation, development of design guidelines, and development of advanced structural systems, which strongly support the steel construction industry in Canada.

The HTS system includes a hybrid simulation controller, workstation, hydraulic service manifolds and two long-stroke (+/-500 mm) high capacity (1000 kN) hydraulic actuators capable of applying high frequency loading. An application of the HTS in evaluating the response of a steel moment frame structures is shown below. As shown, a beam-to-column subassembly is tested experimentally and the rest of the structure is modeled numerically under a seismic ground motion record. In addition to its hybrid testing capability, the HTS offers quasi-static testing capability, which will be used to test full-scale structural members under static loading, with higher precision and reliability.




*HTS system: The structure's response is numerically simulated while the experimental element is loaded using commands generated in the numerical model.*

The Steel Centre partnered with other structural engineering research groups at the University and the federal government's Research Tools and Instruments (RTI) grant program to purchase the $500,000 system, a 1:10 leverage for the Steel Centre's funding. This hybrid testing system is one of only a few hybrid testing facilities of its kind in Canada. Access to similar advanced testing systems would be unreasonably costly for a single organization or company; this partnership provides high-end capability for all researchers at the IF Morrison Structural Engineering Laboratory.

# from research to industry

**Daniel Unsworth shared his research with industry professionals at CanWeld 2018**

**Daniel Unsworth, M.Sc. 2019**

Dr. Robert Driver
Dr. Leijun Li

Research funding provided by

SUPREME GROUP


The CWB Welding Foundation, the non-profit arm of CWB Group, sponsored Steel Centre M.Sc. student Daniel Unsworth's travel to Winnipeg to present on his research into residual stresses in welded shapes at the annual CanWeld conference. Daniel received the Foundation's 2018 CWB Welding Advancement Award, recognizing excellent research to advance welding knowledge and safety. Daniel's presentation, titled *The Effects of Residual Stresses on Girder Buckling Behaviour – Lateral Torsional Buckling in Welded Shapes*, gave an overview of how his current research project seeks to better understand residual stresses due to welding and how they affect the lateral–torsional buckling behaviour of welded steel girders and beams. "The research stems from concerns that the current Canadian steel design codes are unconservative when designing welded steel beams," says Daniel. "In the presentation, I outlined the basic theory behind this concern as well as some gaps in knowledge that this project hopes to fill."

cwbwelding foundation
building the future of welding in Canada

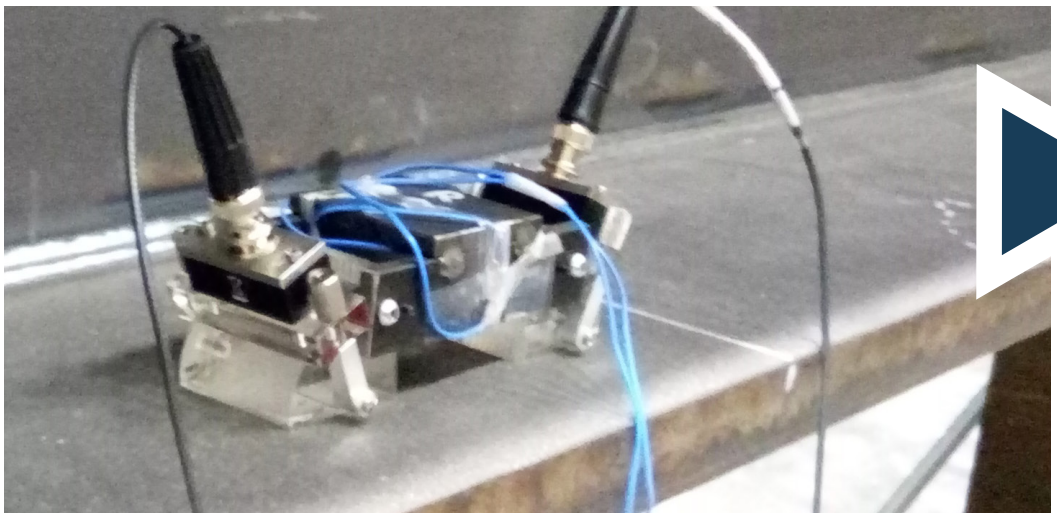
One challenge Daniel's research hopes to address is the prediction of typical residual

stresses in welded girders. Steel Centre founding member Supreme Group provided detailed information on the fabrication procedures of the test specimens they supplied, which helped to identify parameters for these stress distributions. As a result of the testing programme, Daniel determined the accuracy of an ultrasonic system which could be used by others for non-destructive stress measurement.

**Valuable learning**

"Coming from a civil engineering background, I found it valuable to get a sense of the depth of welding beyond just a structural connection method. I saw this not only in the research that goes into advancing welding engineering, but also in the people and community associated with the trade and the diverse backgrounds they come from." Daniel was also able to attend conference sessions and network, including the opportunity to meet with people involved in the development of ultrasonic stress measurement systems, which were used on the research project. He thoroughly enjoyed seeing some of the work CWB Welding Foundation does in local schools: working with at-risk children through combining welding with First Nation's art and culture, and looks forward to seeing where this program will go in the future.

Thank you to the CWB Welding Foundation for supporting Daniel's research through the Welding Advancement Award and for providing this excellent learning opportunity.



An ultrasonic probe takes stress distribution measurements.

# new technology, new directions

**The Steel Centre keeps an eye on emerging technologies and their potential impact on the steel construction industry.**

AJ Darras, the Steel Centre's new Research Assistant, is currently leveraging his experience in computational and generative design to investigate the usage of similar innovative technologies in structural engineering. Generative Design allows designers, architects, and engineers to define a problem, its constraints, and high-level goals to solving it, like reducing cost or amount of wasted material. Then the computer uses its computational power to generate, evaluate, and evolve—just like nature's evolution—a wide range of solutions.

Generative Design keeps the decision-making power with the engineer, but

## what is generative design?

Generative design combines an engineer's knowledge with the infinite experimentation of computer-driven systems. An engineer sets constraints, such as overall shape, geometry, load characteristics, and stiffness. Then, optimization patterns are selected, whether to reduce mass or minimize number of parts to assemble. As the new designs are generated, the designer can continue to tweak settings to create sub-patterns until arriving at a solution. In this way, the final design leverages the engineer's knowledge to arrive at solutions that might never have been considered in traditional systems.

Photo credits, clockwise from top left: (1) https://hindustanalcoxlimited.wordpress.com/2015/06/09/top-stainless-steel-space-frame-companies-in-india/, (2) http://architect-1.blogspot.com/2015/09/structure-design-of-Heydar-Aliyev-Center-Zaha-Hadid.html, (3) https://interiors12.wordpress.com/gallery/zaha-hadid-heydar-aliyev-cultural-centre-progress-2/

also allows us to explore solutions we might never have considered. The technology has been used in mechanical engineering and other industries, but has seen limited application in structural engineering. That's where the Steel Centre is set to explore new possibilities.

"Where new technology is taking root, we want to fully understand its potential for our industry," says Steel Centre Director Dr. Robert Driver. "These computer-aided tools are set to shift how engineers approach structural design."

AJ will investigate what our industry needs are, and from those needs the Steel Centre will grow its projects to complement or expand new areas of research. As a result, industry members will get early access to relevant, specific applications of this new field. Look for generative design as a complementary aspect of upcoming research projects.

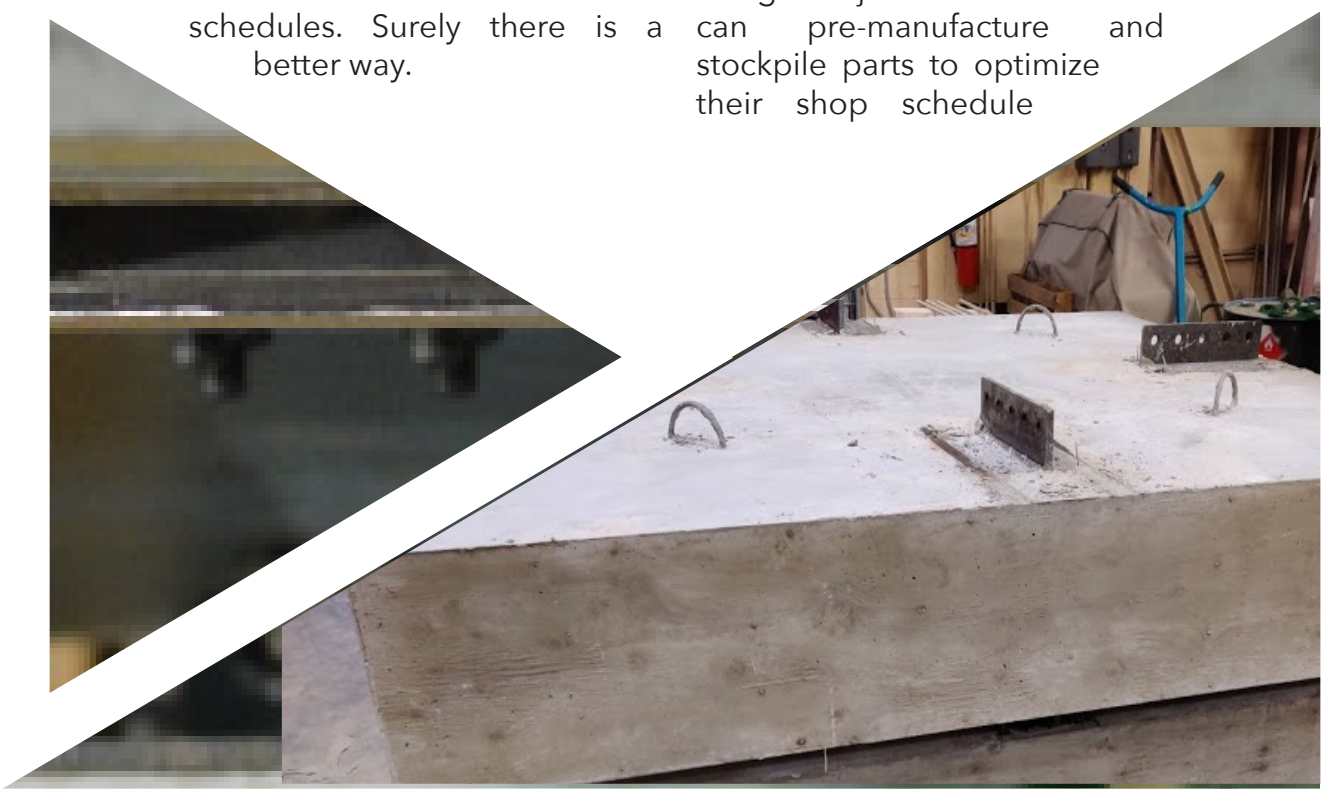
**AJ Darras**
Research Assistant

# industry comes together at the Steel Centre

**Consultants, fabricators, and installers come together to tackle a shared challenge**

Embedded plates are seemingly one of the most unanimously disliked pieces of the construction puzzle. Their numbers can easily range into the hundreds for any given project, with dozens of unique dimensions and designs. This causes an increased workload for designers, who must take time for each project to specify plate designs. Fabricators must produce and track myriad part numbers, and hope that on-site crews are able to identify and place them correctly. The entire process breeds errors and delays, potentially costing thousands in rework and missed schedules. Surely there is a better way.

Steel Centre members DIALOG, Collins Steel, and collaborator Clark Builders met with M.Sc. student Ian Chin and his supervisors Dr. Tomlinson and Dr. Driver for a cross-industry brainstorming session. In this joint setting, pain points could easily be identifed and resolved. The final result: a proposal for a standardized 'catalog' of embedded plates, taking into account real-world scenarios and common configurations. Ian is working to test the physical properties of these plates to generate known capacities, making the designer's job far easier. Fabricators can pre-manufacture and stockpile parts to optimize their shop schedule

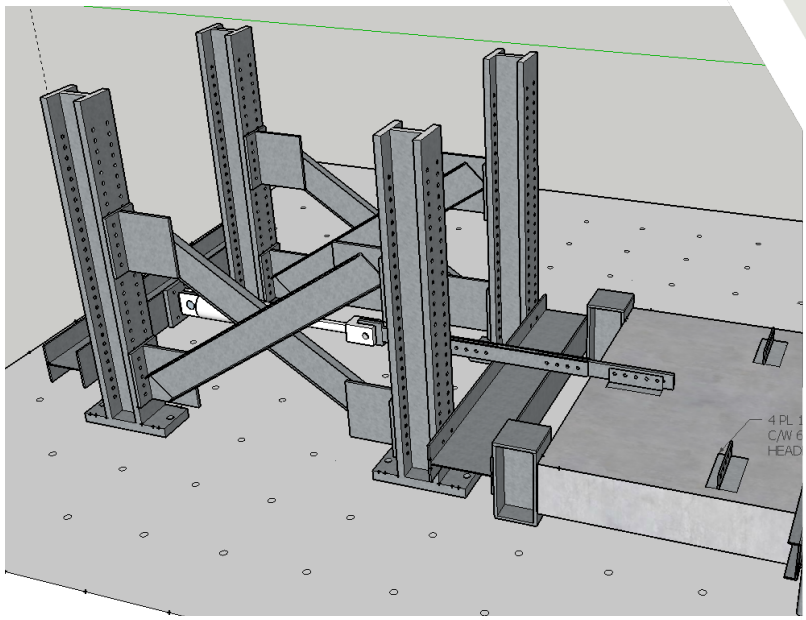


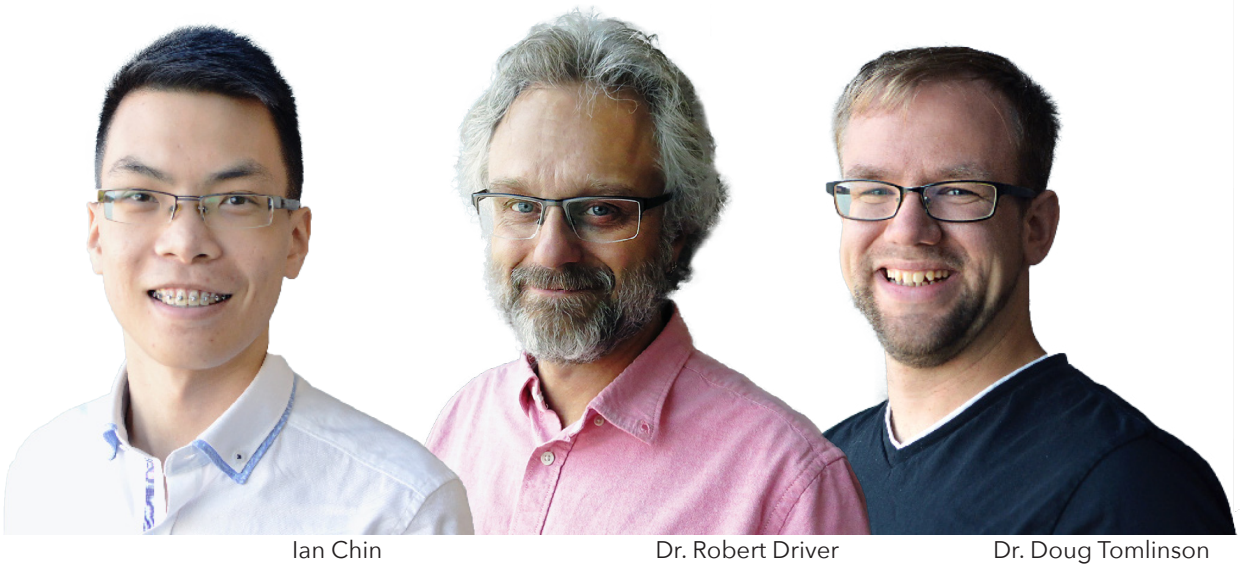
and have immediate turnaround for projects. On site, installers work with a known set of familiar pieces designed to prevent common installation errors such as reversal and rotation.

With this valuable industry insight, Ian will work to develop physical tests to verify the capacity of each plate, providing assurance to consultants as they specify them in future designs. The results of the physical testing programme will help to create a set of standardized embedded plates for common loading conditions to improve the efficiency of the design process, while ensuring the safety of the connection.

When final results are available, Steel Centre member DIALOG and other consultants can begin to specify standardized embedded plates, unchanged from one project to the next and freeing up valuable time to focus on other engineering challenges. Fabricators and installers look forward to seeing fewer errors and rework, while owners will see more projects delivered on-time.

The Steel Centre's unique composition as a body of steel construction industry representatives who work collaboratively across all active research projects enabled a more comprehensive solution, which meets the needs of a variety of stakeholders.





Ian Chin Dr. Robert Driver Dr. Doug Tomlinson

# community

**The Steel Centre once again supports rural communities with engineering expertise.**

For the second year, students from the Steel Centre have participated in building a steel cable suspension bridge in a remote community of Bolivia with Engineers in Action (EIA). EIA guides students as they design and construct a footbridge to connect otherwise isolated areas to better health care, improved markets and trade, and increased educational opportunities.

As part of the Bridge Corps, Ian was responsible for engineering oversight during construction. Collaborating with a team of local and international volunteers, masons, and construction specialists, the Bridge Corps helps to ensure a successful installation and monitors safety protocols.

"There were many challenges throughout the project resulting in a slow start of the construction phase," says Ian, "but after seeing how a few hours of rain washed away the community's access road across the river, our team knew we had to finish this bridge. It was extremely rewarding to see it finally serve the community."

This real-world experience extends even beyond the typical conditions found at home: equipment is extremely limited, and many tasks are carried out by hand and ingenuity. Seeing an international-quality bridge arise from limited resources shows a different way of approaching problems in future situations. Congratulations to Ian for taking on this challenge and bringing new opportunities to the community of Humapirhua, Bolivia.

# in the news

**Advantage Steel**
CISC Steel Centre creating impact in Education and Research at the University of Alberta

**Canadian Fabricating & Welding**
CISC Centre for Steel Structures Education & Research aims to bridge divide between industry, academia

**Canadian Institute of Steel Construction (CISC)**
CISC Centre for Steel Structures Education & Research Launches Today!

**Construction Canada**
New learning centre for Canadian steel construction

**Construction Business**
Forging Industry Partnerships

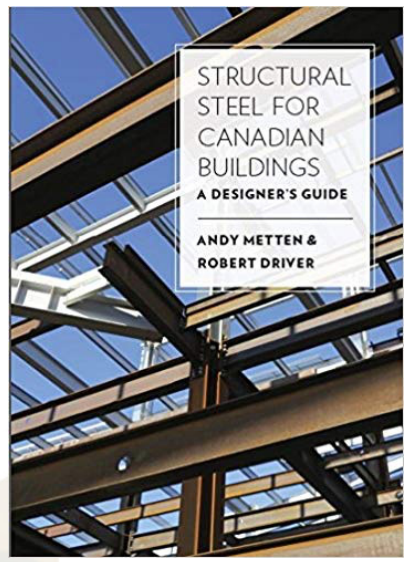
**Daily Commercial News**
University of Alberta's Steel Centre looks to forge the future

**Edmonton Journal**
Steel centre forged for University of Alberta engineers

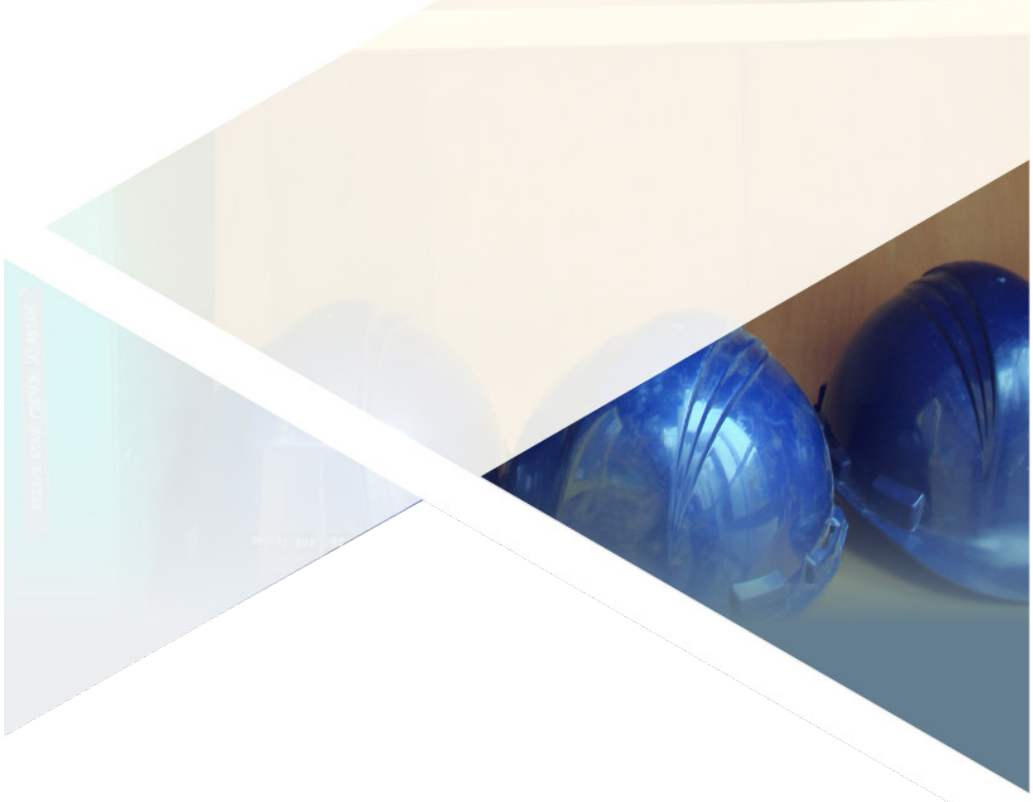
**Journal of Commerce**
University of Alberta's Steel Centre looks to forge the future

# practice-oriented textbook

Steel Centre Director Dr. Robert Driver has co-authored a new design textbook for professionals and students alike. ***Structural Steel for Canadian Buildings*** (Metten and Driver 2016) presents a practical, design-office approach to designing structural steel buildings. It covers topics not traditionally treated in steel design books, including the conceptual design of roof and floor decks, open web steel joists, and hollow structural section steel trusses, the review of shop drawings, and an introduction to seismic design of steel structures. The book considers steel design by examining the entire structural system and the ways in which individual elements fit within the structural system as a whole. Current design practice is demonstrated using worked examples.




The text has been written for practising engineers who wish to keep current. Fourth-year and graduate-level engineering students will also find it relevant to their studies. The book integrates all aspects of Canadian steel design and is essential reading for Canadian engineers who design with steel. The book presents the reader with a practical approach to steel design that will be beneficial to engineering students who hope to work in a consulting design office and to those who already work in structural steel design.



# new Steel Centre publications in 2019

Steel Centre students underlined.


Ashrafi A, Imanpour A. (2019). Analytical Assessment of the Seismic Performance of Two-tiered Eccentrically Braced Frames. Pacific Structural Steel Conference, Tokyo, Japan Nov. 9 – 11.

Agbo S, Lin M, Ameli I, Imanpour A, Duan D-M, Cheng R, Adeeb S. (2019). Evaluation of the Effect of Internal Pressure and Flaw Size on the Tensile Strain Capacity of X42 Vintage Pipeline using Damage Plasticity Model in Extended Finite Element Method (XFEM). ASME 2019 Pressure Vessels & Piping Conference PVP2019, San Antonio, TX, U.S. July 14-19.

Agbo S, Li M, Ameli I, Imanpour A, Duan D-M, Cheng R, Adeeb S. (2019). Experimental Evaluation of the Effect of the Internal Pressure and FlawSize on the Tensile Strain Capacity of Welded X42 Vintage Pipelines. *International Journal of Pressure Vessels and Piping*, 173: 55–67.

Ashrafi A, Imanpour A. (2019). Seismic Response of Steel Multi-Tiered Eccentrically Braced Frames. 12th Canadian Conference on Earthquake Engineering, Quebec City, QC, Canada, June 17-20.

Cano P, Imanpour A. (2019). Dynamic Analysis of Steel Multi-Tiered Special Concentrically Braced Frames. ASCE Structures Congress. 2019 ASCE Structures Congress, Orlando, FL, U.S., April 24-27.

Cano P, Comeau C, Imanpour A**,** Tremblay R. (2019). Full-Scale Test Program for the Seismic Performance of Steel Multi-Tiered Concentrically Braced Frames. Pacific Structural Steel Conference, Tokyo, Japan Nov. 9 –

Daneshvar, H., Oosterhof, S.A., and Driver, R.G. (2019) "Arching followed by catenary response of steel shear connections in disproportionate collapse." *Canadian Journal of Civil Engineering*, DOI: 10.1139/cjce-2018-0645, online publication date: September 24, 2019.

Daneshvar, H., and Driver, R.G. (2019) "One-sided Steel Shear Connections in Progressive Collapse Scenario." *Journal of Architectural Engineering*, American Society of Civil Engineers, vol. 25, no. 2, 15 pp. DOI: 10.1061/(ASCE)AE.1943-5568.0000354; online publication date: February 26, 2019.

Driver, R.G., and Jeppesen, M. (2019) "CISC Steel Centre Hits the Road–As it Continues to Challenge Traditional Boundaries", *Advantage Steel*, Summer Edition, Canadian Institute of Steel Construction, Markham, ON.

Unsworth, D., Li, L., and Driver, R.G. (2019) "Lateral–Torsional Buckling in Welded Girders: Prediction and Measurement of Residual Stresses." Paper MAT100. Proc., 7$^{th}$ *International Engineering Mechanics and Materials Specialty Conference*, Canadian Society for Civil Engineering, June 12-15, Laval, QC, Canada.


Ji, X.L., Driver, R.G., and Imanpour, A. (2019) "Large-scale Lateral–Torsional Buckling Tests of Welded Girders." Proc., *Annual Stability Conference*, Structural Stability Research Council, April 25, St. Louis, MO, USA.

Ji, X.L., Driver, R.G., Imanpour, A. (2019) "A Question of Stability: Reassessing Lateral–Torsional Buckling Capacity of Modern Welded Steel Girders" *Advantage Steel*, Spring Edition, Canadian Institute of Steel Construction, Markham, ON.

Ji X-L, Driver R-G, Imanpour A. (2019). Large-scale lateral–torsional buckling tests of welded girders. Annual Stability Conference Structural Stability Research Council, St. Louis, MO, U.S., April 2-5.

Imanpour A, Torabian S, Mirghaderi R. (2019). Seismic Design of the Double-Cell Accordion-Web Reduced Beam Section Connection. *Engineering Structures*, 191: 23–38.

Ji, X.L., Driver, R.G., and Imanpour, A. (2019) "Large-scale Lateral–Torsional Buckling Tests of Welded Girders." *Steel Centre Engineering Report No. 015*, October, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Canada, 162 pp.

Koch, J.C., Driver, R.G., Li, Y., and Manarin, M. (2019) "Evaluation of CSA S16-14 Asymmetry Parameter for Singly-symmetric Beams." *Canadian Journal of Civil Engineering*, vol. 46, no. 3, pp. 230235. DOI: 10.1139/cjce-2018-0223.

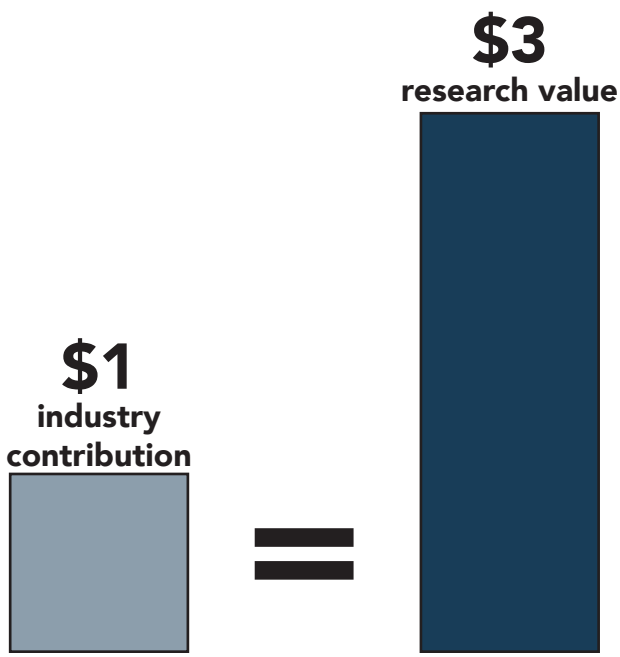
Manarin, M., Driver, R.G., and Li, Y. (2019) "Moment Gradient Factor for Lateral–Torsional Buckling of T-shaped beams." Proc., *Annual Stability Conference*, Structural Stability Research Council, April 25, St. Louis, MO, USA.

Manarin, M., Driver, R.G., and Li, Y. (2019) "Numerical Investigation of Lateral–Torsional Buckling of T-shaped Steel Beams." *Steel Centre Engineering Report No. 016*, October, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Canada, 168 pp.

Unsworth, D., Driver, R.G., and Li, L. (2019) "Characterization of Residual Stresses in Modern Welded Girders." *Steel Centre Engineering Report No. 014*, October, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Canada, 150 pp.


# financial overview

2019 at the Steel Centre saw the continuation of several ongoing research projects and the growth of education programs. Because the educational programs have been created with minimal budget requirements, research expenditures are the most significant area of financial investment. Grant funding, in which Steel Centre funds are applied toward research grants to receive matching funds, are the major means of accomplishing the Steel Centre's work. In 2019, a leveraging ratio of $3 for every industry dollar was achieved for research operations, and $10 for every industry dollar for capital expenditures.




Because of the Steel Centre's ability to use matching funds for the majority of expenditures, combined with the University of Alberta's significant secondary support for researchers, students, and infrastructure, every dollar of industry membership fees has three dollars of effective purchasing power.

# Steel Centre members

The Steel Centre is strengthened by enthusiastic support from our industry partners, who represent every step in the construction process: design, analysis, fabrication, and construction. Founding members Collins Steel Ltd., Waiward Steel LP, Supreme Group, Price Steel Ltd., and TSE Steel Ltd. sowed into a vision for an industry–academic hub to spark new ideas for the steel construction industry and engineering education. In just two years, four more organizations have joined this mission: WF Steel & Crane, DIALOG, and S-Frame Software Inc. Throughout the process, the Canadian Institute of Steel Construction (CISC), the nation's premier industry association, has supported and promoted the Steel Centre's efforts.

Our growth continues into 2020 as more organizations join our mission to imagine and transform the future of structural steel education and construction.

# the STEEL centre

cisc icca

SUPREME GROUP

COLLINS STEEL EST. 1994

WF STEEL & CRANE

Waiward

DIALOG®

S-FRAME SOFTWARE

TSE TSE STEEL LTD.

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