the STEEL centre

2023

ANNUAL REPORT

Dr. Robert Driver
Director

UNIVERSITY OF ALBERTA

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

challenge
traditional
boundaries.

UNIVERSITY
OF ALBERTA

the STEEL centre

empowering fu

knowledg

gr

collabo

innovation

excellence

creativity

skill acquisition

success

networking

life-long learn


tures
support
experience
ge
owth
ration
mentorship
discovery
exploration
ning

contents

from the director

The Steel Centre is turning 8, and continues to "challenge traditional boundaries"! It then seems appropriate to check in with the original goals and aspirations of this innovative, close relationship with local and regional industries. There are two main things that make the Steel Centre unique: it is funded entirely by ongoing annual industry support rather than university endowments or government underpinnings, and it is student-centred and maintains a steadfast focus on mentorship and curated experiences for future structural engineers. Over the eight years since its formation, the Steel Centre has developed innovative experiential learning programs for students such as the "Steel Squad", "SCORE" (Steel Centre OutReach Engineering), "SuperTour", "SCILS" (Steel Centre Industry Launchpad for Students), "Steel for Lunch", "Industry-ready", as well as actively supporting student participation in Engineers in Action (originally part of Bridges to Prosperity) and the National Steel Bridge Competition.

In early 2017, the Steel Centre hosted two all-day workshops to tease out a complete strategic plan with the involvement of many industry leaders, both from member companies and non-members, which was highly successful and to this day provides inspiration and focus for our rich suite of activities. Some of you reading this may have been involved in that original workshop series, but for others, our key elements of the Steel Centre Strategic Plan, outlined on pages 6-7, are: **Vision, Mission, Values, and Strategic Directions.**

As you might have guessed from the heading of this article, we have adopted our first "Value" as our ubiquitous tagline. "Challenge traditional boundaries" is a general philosophy that is at the very heart of our success and speaks to how the Steel Centre uses innovative thinking to create experiential learning programs that exist nowhere else. Students continue to benefit from experiences that are designed specifically to complement their formal degree programs and from the support and participation of our great member companies.

Thank you to all of our Steel Centre members for your ongoing support of steel construction research and enriching the student experience!

Dr. Robert Driver
Founding Director
The Steel Centre

CANADIAN INSTITUTE OF STEEL CONSTRUCTION

C.W. CARRY CHAIR in Steel Structures

SUPREME STEEL PROFESSORSHIP in Structural Engineering Education and Innovation

UNIVERSITY OF ALBERTA

the STEEL centre

vision

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

mission

We are an **industry-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!**

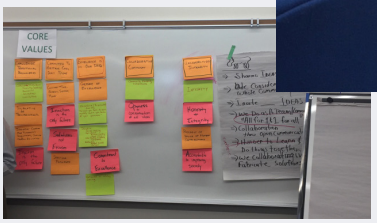
strategic directions

Build a **culture of collaboration and trust**.
Develop a **diverse network**.
Enrich the **educational experiences** of our students.
Identify and seize opportunities that add **value to industry**.
Co-create and communicate member value.

a story of growth

The Steel Centre began as an idea to more closely integrate industry and academic research. That initial vision has grown and developed in unprecedented ways, leading to a collection of programs and projects to invigorate engineering education and train top-quality engineers for tomorrow.

April 2017
Visioning and Strategic Planning Workshops: participants from industry and the UofA set a course for the future.

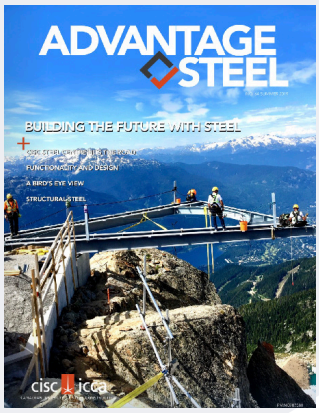


October 2016
Public Launch of CISC Centre for Steel Structures Education and Research with Dean Fraser Forbes.

December 2017
Steel Squad officially announced; first event at Collins Steel.

2016

February 2017
Dr. Ali Imanpour is the first full-time professor hired for the Steel Centre.



May 2019
Steel Centre is featured in CISC's national industry magazine.

SUPER TOUR
by the STEEL centre

June 2023
Students visited British Columbia for an immersive educational experience, exploring remarkable structures and technological marvels that reshaped the world of engineering.

July 2018
SCORE, a student-run consultancy, launches. Graduate students complete real-world projects for member organizations.

S.C.O.R.E.
by the STEEL centre

2023

June 2018
Brown Paper exercise spurs new areas of development for the Steel Centre's continued growth.

T3
by the STEEL centre

April 2021
T3, the technology think tank at the Steel Centre, looks at the biggest problems facing industry.

February 2023
I.F. Morrison Structural Laboratory reopens with significantly expanded space for physical testing and a new, larger strong wall and strong floor system–designed by our very own S.C.O.R.E. team

UNIVERSITY OF ALBERTA

learn by doing

The Steel Centre brings learning to life with hands-on experiences to frame and contextualize the design and construction process. Students see how engineers, trades workers, and general contractors work together to take buildings **from draft to delivered.**

Learning from the designer, standing alongside the finished structure gives students deep insight into the holistic nature and interconnectedness of components and how design decisions are made.

Industry partners **keep students up-to-date with cutting-edge tech** that will be commonplace in the workplace of tomorrow. Students arrive to their first day with background knowledge of the tools and systems that they will encounter in their professional practice.

COLLINS STEEL
WF STEEL & CRANE
CANAM Better Building Solutions
SUPREME STEEL
DIALOG
IDEA StatiCa
ALTAIR
cwbwelding foundation
TSE TSE STEEL LTD.
STEADFAST ENGINEERING LTD
niik Nik Group

CANADIAN INSTITUTE OF STEEL CONSTRUCTION
C.W. CARRY CHAIR in Steel Structures
SUPREME STEEL PROFESSORSHIP in Structural Engineering Education and Innovation

experiential learning

Steel Centre OutReach Engineering (SCORE) is a student-run consultancy that takes on real projects alongside industry partners, building authentic mentorship relationships and training students in **hands-on engineering.**

The Steel Squad offers unique opportunities for undergrads to **experience steel construction live and in person:** at active job sites, fabrication shops, in engineering offices, and beyond.

Steel Centre Industry Launchpad for Students (SCILS) is a unique and flexible way of matching students with industry partners for summer work experiences that give them professional skills that help them to stand out when launching their careers.

Steel for Lunch is a Friday lunchtime series that explores topics of interest to the steel construction community. Case studies, research presentations, and professional advice are all on the menu. **Students and practicing engineers come together** to learn and share their experiences first-hand.

Students are **recognized for these additional experiential learning opportunities** through the Steel Centre Industry-Ready endorsement. Motivated students complete a series of learning experiences across core areas to **develop their abilities outside the traditional curriculum**, making them more "Industry-Ready" on day one of their future careers.

The Steel Centre Bridge Team is an extraordinary group of talented individuals with a shared vision of elevating traditional structural engineering boundaries. Their mission is to **engineer excellence while fostering a culture of innovation and teamwork** that empowers students to excel as the engineers of tomorrow.

The **SuperTour** is a chance for students to travel with their professors outside of Alberta and spend a week in an **immersive experience** that takes them on a comprehensive exploration of cities known for their remarkable structures. This unforgettable journey serves as **a foundation for students to witness firsthand** the awe-inspiring creations and technological marvels that reshaped the world of engineering.

SCORE

by the STEEL centre

Steel Centre OutReach Engineering (SCORE) is a student-run engineering consultancy by the Steel Centre. Students work with member organizations to take on real projects, developing authentic mentorship relationships and increasing their real-world experience while still in training.

SCORE has worked across a range of engineering specialties, from software design to improve the interoperabiilty of connection design software to numerical analysis to confirm design decisions for complex details. SCORE even received mention as part of the engineering team for the newly renovated Morrison Structural Laboratory at the UofA, where SCORE designed the strong wall and strong floor under the supervision of Steel Centre member DIALOG.

What's to come? We see continued and growing partnerships within our membership, along with new opportunities to collaborate with companies across Alberta. SCORE has proven to be a capable, highly competent team, and the working partnerships have been overwhelmingly positive for students and professionals alike.

Interested? Great! SCORE is open to new project proposals.
Get in touch at score@steelcentre.ca.

Guidelines for modelling, analysis, and design of Open Web Steel Joists

Omid Moammer, Ph.D.
Supervisor: Dr. Ali Imanpour

The current SCORE project is an ongoing collaborative and comprehensive effort with Steadfast Engineering. The project team includes Ph.D. students, Omid Moammer and Mahdi Mokhtari, as well as M.Sc. student, Sepehr Pessiyan, and undergraduate Steel Squad students, Johnson Kau and Jonathan Werner.

The project initiation involved a crucial kickstarter meeting with Steadfast, where the team collectively discussed and delineated the project's scope. This foundational step set the trajectory for the subsequent phases of the project. The team then directed their attention towards a detailed exploration of CSA S16 code requirements for Open Web Steel Joists (OWSJs). As they progressed, they delved into the intricacies of SAP2000, a critical aspect of the project, addressing the essential procedures for modeling OWSJs in accordance with CSA S16.

Given the expansive scope of the project, scheduling meetings that accommodated everyone's availability posed a challenge. However, the team successfully navigated this hurdle, ensuring that each member had the opportunity to contribute to the discussions. Despite this achievement, the complexity and thoroughness of the project extended the anticipated timeframe, highlighting the commitment of the team to maintaining the quality and precision of their work. This extension, while beyond the initial expectations, attests to the team's dedication to delivering a robust and well-informed outcome.

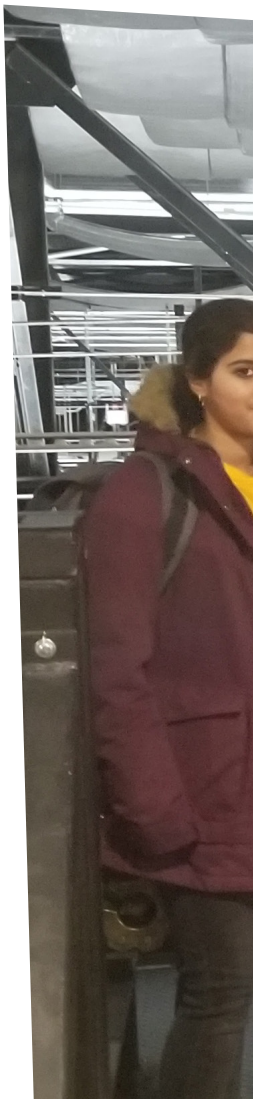
STEADFAST ENGINEERING LTD
STRUCTURAL ENGINEERING CONSULTANTS

UNIVERSITY OF ALBERTA

The Steel Squad is a selective-entry undergraduate group for students with an expressed interest in steel construction. Squad members get special access to active jobsites, industry leaders, and training opportunities. In 2023, the Squad toured one of the most exciting buildings in Edmonton, Rogers Place!

This technical tour encapsulated the entire facility, with the highlight being the massive steel roof structure. The Squad walked the catwalks at roof level (above the iconic clock/scoreboard) to get an appreciation of the engineering involved in designing and constructing such a unique structure. In addition to touring other structures around and under Rogers Place, the Squad learned about some of the challenges involved in regulating temperature and humidity, particularly in a dry climate like Edmonton's, to keep the ice quality rated among the best in the NHL.

Being able to tour elements of construction that are not part of the core curriculum helps to immerse future engineers in the full context of the construction process. This provides tangible reminders of how design decisions can have profound effects on constructability, efficiency, and cost. Engineers who better understand and appreciate the skills of their construction industry colleagues think more holistically about their role and ask more questions to help ensure their plans make sense to all involved.



Above: The Steel Squad visit the special players areas of Rogers Place

Below: Students tour the roof of Rogers Place and see how steel is constructed to support internal and external elements

Steel Centre graduate, **Fardad Mokhtari**, recently completed a Mitacs Lab2Market project entitled **"SafeSite: AI-driven Web Application Designed for Safety Management in Construction"** as a Mitacs post-graduate intern in the Steel Centre's SCILS program. This research project targeted the need for improved safety management through proactive rather than reactive measures. The primary goal of this internship was to assess market demand among small to mid-size construction companies for a new product, SafeSite, an AI-driven web application designed to predict potential safety hazards on construction sites. This was achieved through a combination of qualitative interviews with industry professionals and quantitative market analysis. Key outcomes of the project include the identification of market opportunities for AI in safety management and the laying of groundwork for potential future development and intellectual property creation.

Fardad Mokhtari

Moreover, the internship provided valuable insights into the feasibility of AI applications in construction safety, showing promise for significant improvements in proactive safety measures. Overall, this project suggests that SafeSite has the potential to revolutionize safety management in construction, indicating a strong prospect for future industry adoption and

Steel for Lunch lunchtime webinars take students behind the decision-making process used for projects such as the Montréal Olympic Tower restoration and a tsunami evacuation tower on the BC coast. Direct access to the engineers who designed and oversaw construction enhances student awareness and creates connections to practicing professionals.

One seminar in 2023 involved updates to the seismic load in the 2020 National Building Code of Canada from Professor Robert Tremblay, Polytechnique Montréal.

The Steel Centre is proud to sponsor the **UAlberta Steel Bridge Team on their path to 2024!** The club is focused on designing and building a steel bridge in order to compete at the **Canadian National Steel Bridge Competition**. As a team, they are committed to dedication and innovation in developing creative solutions, as well as elevating traditional structural engineering boundaries. To help along the way, the Bridge Team is given tremendous support from Steel Centre Members like Collins Steel and Niik Group.

industry-ready

Students are recognized for these additional experiential learning opportunities through the **Steel Centre Industry-Ready endorsement.** Motivated students complete a series of learning experiences across core areas to develop their abilities outside the traditional curriculum, making them more "Industry-Ready" on day one of their future careers.

STEEL centre INDUSTRY-READY

24 credits in total

at least **6 credits** per core area

maximum **3 credits** per event type

sample student portfolio

real-world engineering	industry collaboration	business sense
Steel for Lunch 1	CISC webinar	SCRG event coordinator
Jobsite visit 1	Office shadowing	Steel for Lunch 2
Engineers in Action*		Engineers in Action*
SCORE*	SCORE*	SCORE*
Summer internship*	Summer internship*	Steel for Lunch 3
Jobsite visit 2		

**Large or particularly complex projects may qualify for a maximum of 3 credits*

SuperTour

The SuperTour, as the name implies, is the tour of all tours! Students get a chance to travel with their professors outside of Alberta and spend a week in an immersive experience that takes them on a comprehensive exploration of cities known for their remarkable structures. This unforgettable journey serves as a foundation for students to witness firsthand the awe-inspiring creations and technological marvels that reshaped the world of engineering.

In 2023, students visited three cities: Vancouver, Nanaimo and Victoria, BC, each with its own architectural wonders and offering a distinctive perspective on the application of steel in construction. The SuperTour engaged with over 12 companies, leading to more than 20 different site visits. These companies graciously open their doors to the students, providing insights into their day-to-day workflows and innovative projects. By connecting students with industry professionals, the SuperTour creates a bridge between academia and the practical world, nurturing a holistic understanding of steel structures.

2023

The importance of hands-on experience in developing future leaders cannot be overstated. The SuperTour sheds light on the significance of team collaboration, safety awareness, innovation and creativity, project management skills and understanding of the materials and processes in their academic programs.

By immersing themselves in real-life projects, students gain a deeper understanding of how the real world works; developing critical thinking skills and real-world knowledge that will be invaluable throughout their careers. This experience is an integral part that helps in the development of well-rounded and effective engineers. It complements theoretical learning and prepares students for the challenges they will face in their engineering careers. The program has the potential to become an annual tradition!

people

current students

researchers

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

Dr. Ali Imanpour, P. Eng.
Associate Professor
Steel Structures

Dr. Doug Tomlinson, P. Eng.
Associate Professor
Steel/Concrete Composite Systems

support

Matt Jeppesen
Programs Administrator

Tyler Daignault
Student Experience Coordinator

Greg Miller
Structural Engineering Technician

Cam West
Structural Engineering Technician

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

Dr. Yong Li
Associate Professor
Reliability & Advanced Analysis

Dr. Ali Sadrara
Post-doctoral Fellow
Steel Structures

2023 highlights

New SC Staff

Welcome, Tyler Daignault, the new Student Experience Coordinator for the Steel Centre! Tyler is a graduate of the UofA (BA '05), and is excited to be back on campus working with students and researchers. He brings nearly two decades of experience in marketing, client relationships, and event planning.

First Research Project to Partner with All Steel Centre Members

The Decision Support Systems for Steel Construction project kicked off September 2023 that aims to produce tools that can help industry professionals make better and informed decisions, which will benefit the steel construction industry and Canadians in general.

I.F. Morrison Structures Lab Reopens

The University of Alberta's structural engineering lab reopened with significantly expanded space for physical testing and a new, larger strong wall and strong floor system–designed by our very own SCORE team, in collaboration with Steel Centre member DIALOG. A very exciting student-led endeavour, whose work will now be used in a new era of structural engineering at the UofA.

Additional thanks to DIALOG for supporting as co-hosts to inaugurate the lab with a grand re-opening celebration hosted by Steel Centre Director, Robert Driver. We all appreciated a chance to connect with industry colleagues and reminisce about the many projects and generations of engineers who have been trained through the research programme at the IF Morrison Structures Lab.

student awards 2023

Steel Centre students are top performers, receiving a number of honours and awards each year for academic and research accomplishments. In 2023, students were awarded scholarships totalling a teriffic $84,700. The Steel Centre's excellent students have attracted direct support from outside organizations like the CWB Foundation's Welding Advancement Award, given each year to a Steel Centre student or students whose research advances the welding field. We are honoured by this support, and proud of our students and their accomplishments.

cwbwelding foundation
building the future of welding in Canada

$84,700 total awards & scholarships in 2023

- CISC Alberta Region G.L. Kulak Scholarship ($15,000)
- Alberta Graduate Excellence Scholarship (2 recipients; $12,000 each)
- NSERC Canada Graduate Scholarship - Master's ($17,500)
- Walter H. Johns Graduate Fellowship ($7,100)
- University of Alberta Graduate Recruitment Scholarship ($5,000)
- Norman and Tess Reid Graduate Scholarship ($5,000)
- Brian Gerbrandt Memorial Graduate Scholarship (2 recipients; $4,300 each)
- CWB Foundation Welding Advancement Award ($2,500)

Legend

National award
Alberta award
University of Alberta award
Steel Centre exclusive award

graduating students

Eric Duong, M.Sc.

Automation of Steel Shear Connection Design using Generative Design

Dr. Imanpour & Dr. Driver

Moad Bani, M.Sc.

Seismic Response and Design of Steel Multi-Tiered Buckling Restrained Braced Frames

Dr. Imanpour

Abolfazl Ashrafi, Ph.D.

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

Dr. Imanpour

Ahmed Mowafy Saad, Ph.D.

Advanced Hybrid Steel-Timber Structures for Seismic Applications

Dr. Imanpour, Dr. Chui

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 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.

A new Emerging Technologies stream is taking shape, using generative design and AR applications to understand new ways to design, build, and teach.

See the list at right for a snapshot of significant areas of research at the Steel Centre.

research topics

structural stability

Improved Beam Design Equations for Welded Steel Girders

Evaluation of Uniaxial Material Models in Predicting Hysteresis Response of Hollow Structural Section Braces

Experimental Evaluation of Stability of Single-Overhanging Steel Girders

Field Testing of Buried Pipelines Under Ground Deformation

Stability Response and Design of Steel Cantilever Systems

Numerical Evaluation of Stability Response of I-Shaped Welded Steel Girders

emerging technologies

Development of Surrogate Models for Braces in Steel Concentrically Braced Frames

Automation of Steel Shear Connection Design using Generative Design

Data-Driven Decision Support System for Design of Steel Girder Bridges

decision support systems

Data Analysis Platform for the Development of Decision Support Systems for Steel Construction Projects

Decision Support Systems for Connections Design and Cost Estimating Analysis in Steel Construction Projects

Connection Design Automation for Steel Construction Projects

seismic design

Evaluation of the Nonlinear Response of Reinforced Concrete Bridge Piers Before and After Seismic Retrofit

Seismic Response and Design of Chevron and Split-X Steel Concentrically Braced Frames

Cyclic and Fatigue Performance of Steel Buckling-Restrained Braces Subjected to Ground Motion-Generated Displacement

Pseudo-dynamic Hybrid Simulation of Steel Eccentrically Braced Frames with Unbraced Links

Seismic Response and Design of Steel Multi-Tiered Buckling Restrained Braced Frames

Design Methods and Modelling Techniques for Steel Multi-Tiered Concentrically Braced Frames considering Base Flexibility

Seismic Stability and Design of Wide-Flange Columns in Steel Frame Structures

Development and Experimental Validation of Machine Learning-based Model Updating Techniques for Steel Braced Frames

Resilient Hybrid Steel-Timber Structural Systems for Seismic Applications

Seismic Response and Design of Steel Multi-Tiered Eccentrically Braced Frames

Nonlinear Modelling of Steel Buckling-Restraint Braces

prefabricated structures

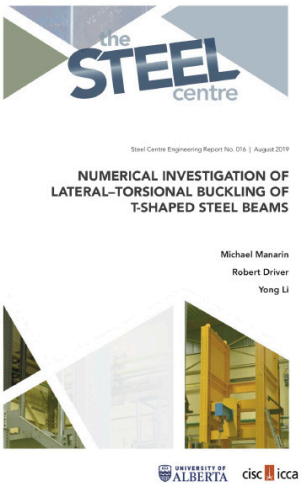
Alternative Design of Column Web Doubler Plates in Steel Pipe Rack Modules

Development of Steel Moment-Resisting Knee-Braced Frame for Multi-Storey Buildings

Steel Centre Engineering Reports (SCERs)

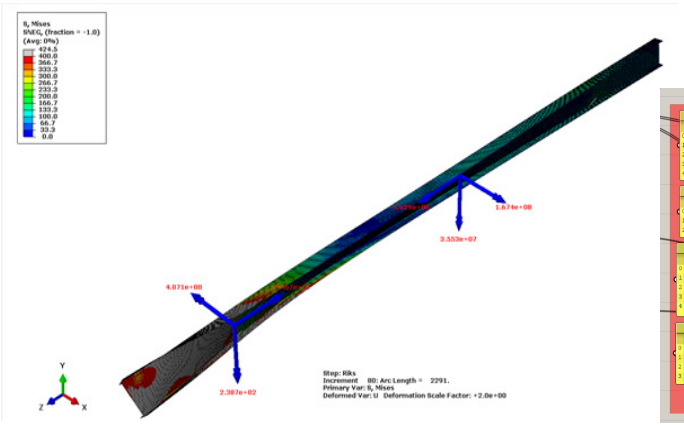
The Steel Centre keeps industry in the loop with new research

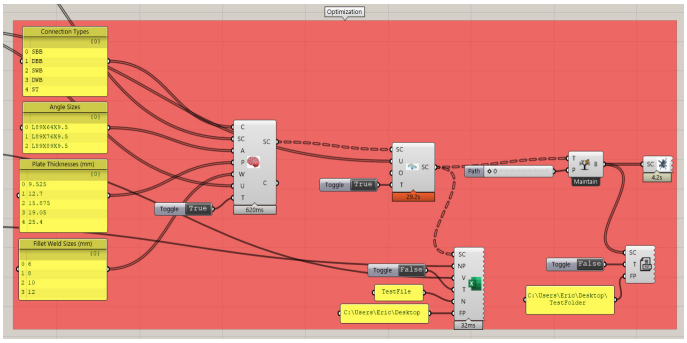
Research is an important part of what we do, but its value is only truly realized when that knowledge can make its way out into the world of practicing engineers. To aid this effort, we launched the Steel Centre Engineering Report (SCER) series. As students complete their investigations, their work is compiled and published as an SCER available to the public.

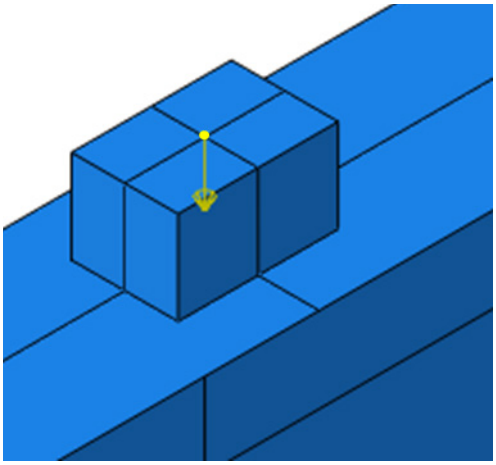


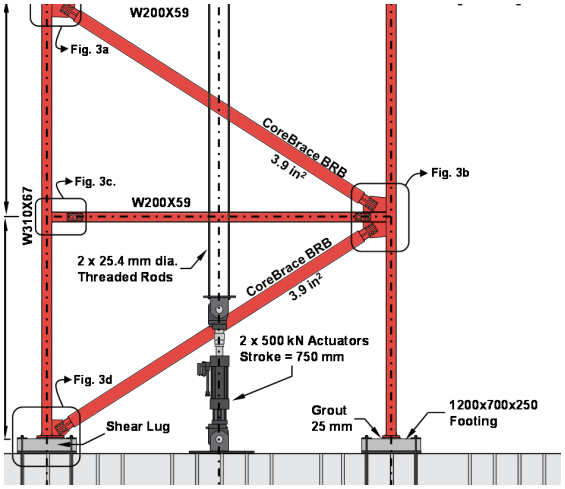
access the reports

[Click here to download any published SCER.](#) The full archive also includes Structural Engineering Reports published by the Steel Centre researchers prior to the Steel Centre's official formation.









Steel Centre publications 2023

Steel Centre students underlined.

Imanpour, A. (2023). "Seismic Response and Design of Steel Multi-Tiered Concentrically Braced Frames Not Specifically Detailed for Seismic Resistance." Journal of Structural Engineering, ASCE, 150(3).

Gharavi, A., Asgarpoor, M., Epackachi, S., Mirghaderi, R., Imanpour, A. (2023). "Axial-Flexural Strength of Steel-Concrete Composite Shear Walls." Journal of Building Engineering, 76, 107122.

Twizell, S., Ji, X-L., Imanpour, A., Driver, R-G. (2023). "Lateral–Torsional and Distortional Buckling of I-shaped Welded Steel Girders." Journal of Structural Engineering, ASCE. 149(9).

Islam, A., Imanpour, A. (2023). "Seismic Stability of Steel Wide-Flange Columns in Ductile Moment-Resisting Frames: Out-of-plane Response and Design Recommendations." Bulletin of Earthquake Engineering. 21, 3493–3519

Mokhtari, M., Imanpour, A. (2023). "Proposed Seismic Design Parameters for the Moment-resisting Knee-braced Frame System." Engineering Structures. 276, 115318.

Asgarpoor, M., Gharavi, A., Epackachi, S., Imanpour, A. (2023). "Nonlinear Modeling for Composite Plate Shear Walls-Concrete Filled Structures." Journal of Building Engineering. 63, 105383.

Mokhtari, F., Imanpour, A. (2023). "A Digital Twin-based Framework for Multi-Element Seismic Hybrid Simulation of Structures." Mechanical Systems and Signal Processing. 186, 109909.

Hosseini, A-S., Mokhtari, F., Imanpour, A. (2023). "A Framework for Multi-Element Hybrid Simulation of Steel Braced Frames using Model Updating." 10th European Conference on Steel and Composite Structures, EUROSTEEL, Amsterdam, Netherlands, September 12 – 14 (Ernst & Sohn, ce/papers Special Issue. 6(3-4): 825-830.

Cano, P., Imanpour, A., Tremblay, R. (2023). "Seismic Performance of Brace Middle-Connection in Steel Concentrically Braced Frames." 10th European Conference on Steel and Composite Structures, EUROSTEEL, Amsterdam, Netherlands, September 12 – 14 (Ernst & Sohn, ce/papers Special Issue. 6(3-4): 1344-1349.

Mowafy, A., Imanpour, A., Chui, Y.H., Daneshvar, H. (2023). "Experimental Investigation of an Innovative Beam-to-Column Connection under Cyclic Loading." World Conference on Timber Engineering, Oslo, Norway, June 19 – 22.

Pessiyan, S., Mokhtari, F., Imanpour, A. (2023). "Artificial Neural Network-Based Hysteresis Model for Steel Braces in Concentrically Braced Frames." CSCE Annual Conference – Structures Specialty, Moncton, NB, Canada, May 24 – 27.

Reyes, W., Imanpour, A. (2023). "Evaluation of Uniaxial Material Models in Predicting Hysteresis Response of Hollow Structural Section Braces." CSCE Annual Conference – Structures Specialty, Moncton, NB, Canada, May 24 – 27.

Kheirkhah-Gilde, M., Lin, M., Cheng, R., Imanpour, A., Yoosef-Ghodsi, N., Adeeb, S. (2023). "A Comparative Study on the Fracture Prediction Capability of XFEM and FEM for Tensile Specimens." CSCE Annual Conference – Structures Specialty, Moncton, NB, Canada, May 24 – 27.

Experimental Evaluation Stability of Single Overhanging Steel Bear

Maha Essa (M.Sc.)
Supervisors: Dr. Ali Imanpour & Dr. Robert Driver

Maha Essa spent one year designing an experimental test setup used to conduct full-scale physical tests of single-overhanging girders at the newly-renovated I.F. Morrison structures lab to accommodate loads and displacements while conforming to the physical testing constraints of the laboratory. The design of the test setup was based largely on preliminary finite element (FE) simulations, conducted by Ph.D. candidate Vahab Esmaeili, of the test specimens, which provided the anticipated loads and deflections in the tests. Prior to testing, initial geometric imperfections, material properties, and residual stresses were measured for all test specimens.

Cantilever-suspended-span construction, also known as the Gerber system, is a prevalent approach for steel roof framing in large single-storey buildings in North America. This system comprises three key components: the back span, cantilever, and drop-in segments. Despite its widespread use and benefits in steel buildings across North America, current steel design standards offer limited guidance on the design of Gerber systems, and no unified design method exists for these systems. Recent structural failures have emphasized the need for a reassessment of the stability response of these systems, particularly in terms of lateral–torsional buckling (LTB) resistance and the exploration of various bracing strategies. To this day, experimental data which reflects the effect of various parameters, such as loading and bracing conditions, on the stability response of the steel Gerber system remains scarce. To address this, a research team at the Steel Centre is performing both numerical and experimental investigations of Gerber systems, with the intention of providing a comprehensive design method for Gerber systems in the framework of the Canadian steel design standard.

Maha Essa

Upon the completion of the design and fabrication of all testing fixtures, Maha worked closely with the lab technicians, Greg Miller and Cameron West, to construct the test frame. Due to the complexity of the test setup, this task took 2.5 months and involved a tremendous amount of fabrication, which led to Maha being trained on almost every piece of machinery in the lab including drilling, punching, band-sawing, flame cutting, angle grinding, and impact wrenching (and even some welding!) in order to finish assembling the frame. Maha then spent 8 months performing full-scale physical testing of 14 W410×85 single-overhanging girders. The girders were 10.97 m long, with back span and cantilever lengths of 9.14 m and 1.83 m, respectively. At both

n of

ms

the end and fulcrum supports, the test girders were simply-supported in-plane and torsionally pinned. Four point loads were applied at 1.83 m intervals along the back span, and a single point load was applied at the tip of the cantilever. The test girders had various loading and restraint conditions provided such that they were predicted to exhibit a failure mode of either inelastic LTB or reaching the full cross-sectional capacity.

The experimental results showed that the addition of a bottom flange lateral brace at the back span load location closest to the fulcrum support has minimal effect on the moment resistance of the girder; however, the addition of this brace leads to a significant beneficial effect on the lateral stiffness of the cantilever segment. It also showed that bracing the top flange of the cantilever tip is more effective at increasing the capacity of the girder compared to adding a bottom flange brace on the back span, and that a bottom flange brace on the cantilever tip was particularly effective at increasing the capacity of the girder. While the testing program provided technical results which lead to enlightenment on the behaviour of Gerber systems, an important lesson which Maha learned through the program had to do with the details of real-world construction which are often overlooked when designing something (such as a test setup) on paper. Despite efforts to address every small detail, last-minute deviations from the design are often inevitable when translating these designs to something concrete. Although the testing program was filled with challenges, Maha sees the good in these challenges for they taught her tremendous adaptability and perseverance.

Alternative Design of Column Web Doubler Plates in Steel Pipe Rack Modules

Hana Chaya (M.Sc.)
Supervisors: Dr. Ali Imanpour & Dr. Robert Driver

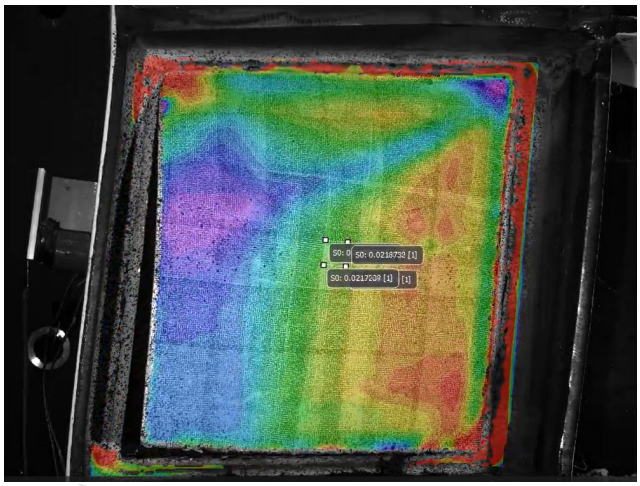
Hana Chaya

Heavy industrial structures are commonly constructed using structural steel. Pipe-supporting structures which are also referred to as pipe racks are an example of these types of structures. They carry the anticipated loads using a gravity load-resisting system combined with concentrically braced frames and moment-resisting frames. Due to similar loading conditions along the network, pipe rack structures are broken into several repetitive volumetric modules that can be prefabricated off-site.

To resist all the loads that these structures anticipate, continuity plates and complex welding applications are used in the design of the connections of these modules. The connections to be designed are beam-to-column moment connections. To transfer flexural bending from beams to the column in these types of connections, web doubler plates are often required when the thickness of the column web is not sufficient to carry the moments. Groove welds are typically used to attach the web doubler plates to the column radius in the connection region. The detail and type of weld can vary from fabricator to fabricator because of the challenges associated with the implementation of such welds in the K-region of the column section. The industry partner of this study (WF Steel & Crane) uses a detail that can be treated as a PJP weld due to the welding position and the inherent difficulty with surface preparation and inspection. The target is the development of an alternative design for steel moment connections used in modular pipe

racks by means of laboratory testing and advanced numerical simulations to improve the fabrication process of such connections.

Hana conducted full-scale tests in the I.F. Morrison Structures Laboratory at the University of Alberta in September 2023. Twelve specimens with different doubler plate details were tested to observe the differences in the behavior and capacities of the proposed alternative details. Two sets of beam to column sections were considered to get a wider range of application of the new detail. The first six specimens consisted of a W250x58 beam and column whereas the next set of specimens consisted of a W410×60 column and a W410×100 beam. Each set of connections had a no doubler plate case, regular doubler plate case, and 4 reduced doubler plate cases. The results of these tests are then used to verify a numerical finite element model which will help predict the behavior of many other beam to column connections with different sections. The purpose is to create a design method that uses fillet welds to attach doubler plates to the column web instead of groove welds. This should facilitate the fabrication process in the shop and lead to a less expensive detail.



the STEEL centre

WF STEEL & CRANE

COLLINS STEEL

CANAM
Better Building Solutions

SUPREME STEEL

DIALOG

ALTAIR

IDEA StatiCa®

cwbwelding foundation

TSE TSE STEEL LTD.

STEADFAST ENGINEERING LTD

niik
Niik Group

CANADIAN INSTITUTE OF STEEL CONSTRUCTION

SUPREME STEEL PROFESSORSHIP
in Structural Engineering Education and Innovation

C.W. CARRY CHAIR
in Steel Structures

steelcentre.ca