



**CONSTRUCTION
INNOVATION CENTRE**
Research Driving Change

ANNUAL REPORT

2023



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Edmonton, AB, Canada



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www.constructionCIC.ca

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INTRODUCTION

WHAT IS THE CIC?

The University of Alberta's Faculty of Engineering established the Construction Innovation Centre (CIC) in May of 2019. Its mission is "to provide breakthrough research, education and training that directly benefit Canada's construction industry and lead to the sustainable and economic development of our built environment and a competitive advantage for the Canadian construction industry."

The CIC brings together more than 30 established faculty members in construction engineering, building science, masonry, steel and water by uniting under one umbrella the Hole School of Construction Engineering, Nasser School of Building Science and Engineering, Masonry Group, and Steel Centre. The CIC is supported by more than 50 partners in industry, professional associations, and funding bodies.

With the help of its partners, the CIC seeks to identify strategic directions for innovation and education and provide the united platform required to coordinate the activities and resources of the wide range of University of Alberta research groups in a manner that maximizes impact for the construction industry, Albertans, and Canada as a whole.

The CIC seeks to become an internationally recognized center for research, teaching, and training in engineering, construction, and servicing the built environment—the focal point around which academia, industry and government can come together to meet the grand challenges facing construction industries and create high-impact innovations across the construction engineering spectrum. We believe in research and innovation that drives change.

CIC Goals

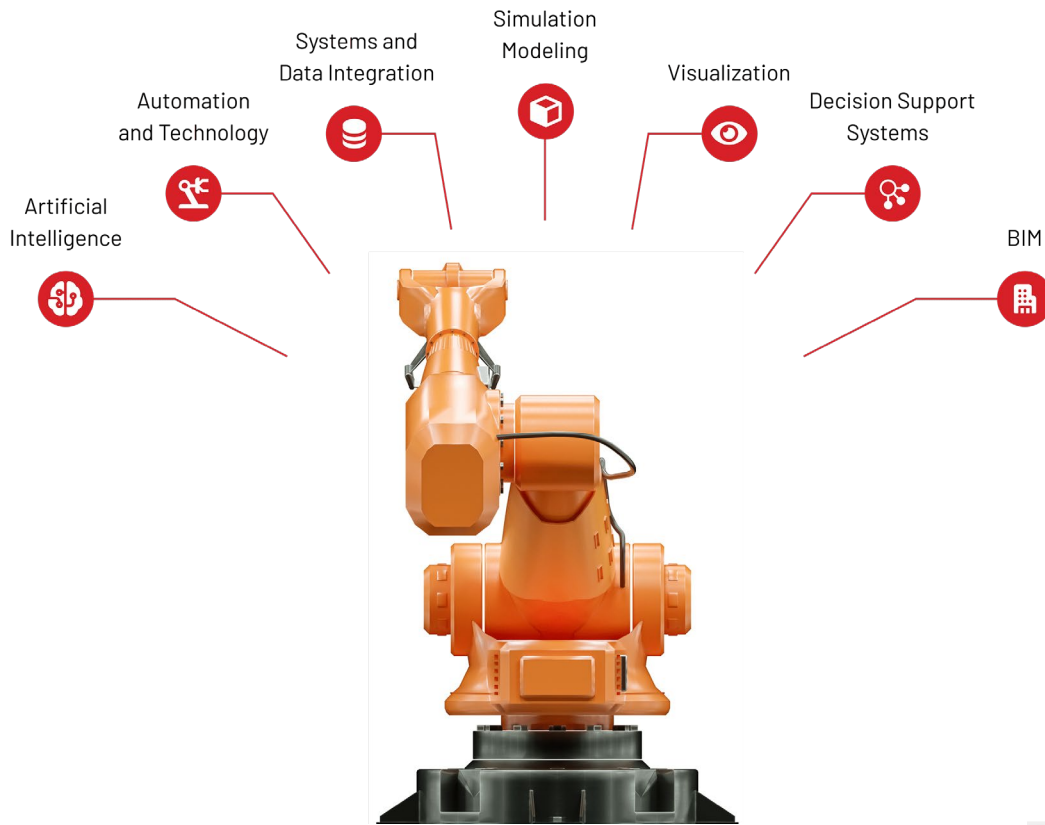
- » Accelerate and support innovation, productivity, and competitiveness in Alberta's and Canada's construction industry, including off-site industries materially impacting construction, through high-impact research projects
- » Identify industry needs and align CIC research programs to meet these needs
- » Provide a unified platform for solutions to construction industry problems through multi-disciplinary research
- » Train the next generation of construction engineers and workforce with leading-edge knowledge and skills
- » Enhance engagement with all levels of government to grow and sustain investment in Canada's construction industry



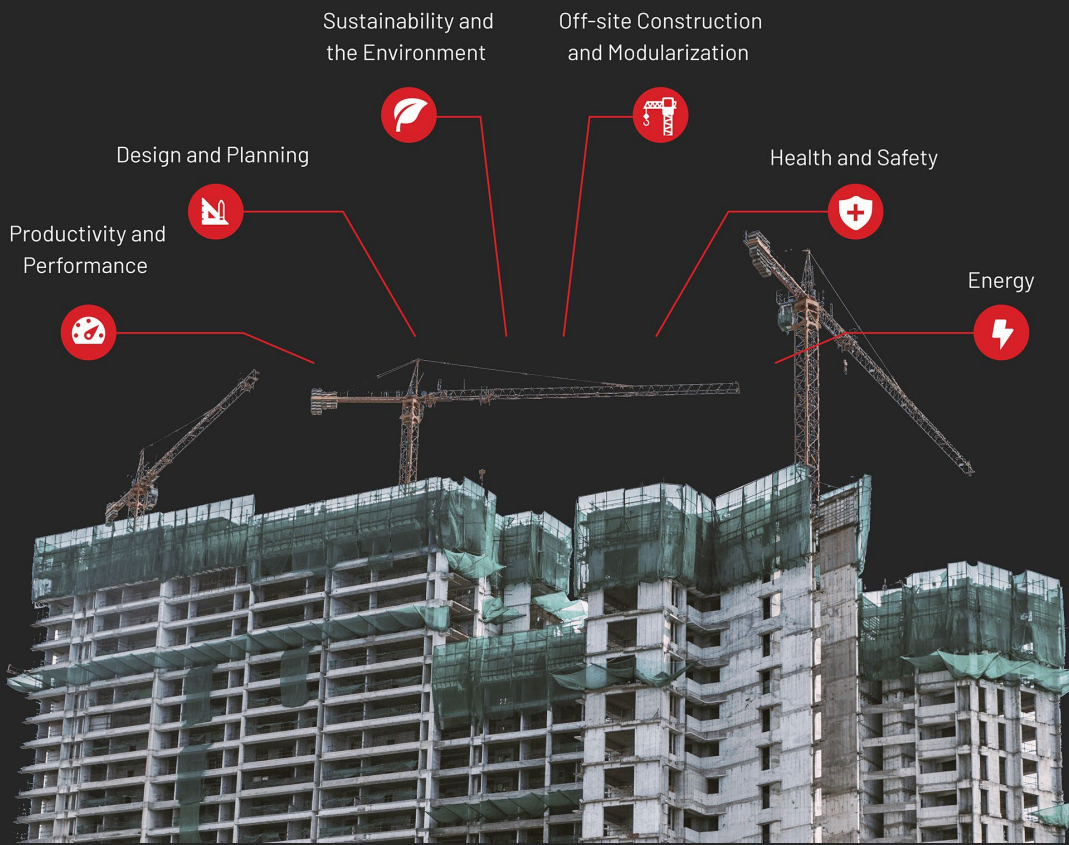
“The CIC aims to provide breakthrough research, education and training that directly benefit Canada’s construction industry and lead to the sustainable and economic development of our built environment and a competitive advantage for the Canadian construction industry.”



Top Research **Methods**



Top Research **Problems**



CURRENT

CIC RESEARCH PROJECTS

Ongoing Research Projects (NSERC/MITACS Approved)

- 01 A Robust and Low-cost Technology for Risk Mitigation of Pathogenic Infection in HVAC Systems
- 02 Artificial Intelligence (AI) Powered Design and Manufacturing for Prefabricated Wood Buildings
- 03 BIM-Integrated Robotics for Intelligent Mass Timber Manufacturing and Operations
- 04 Construction-oriented Digital Twins for Multi-dimensional Production Planning and Control
- 05 Enhanced Perception for Autonomous Truck Mounted Attenuator (ATMA) to Increase Work Zone Safety
- 06 Enhancing Safety Management Systems on Construction Projects: A Data-driven Approach
- 07 Evaluation of Impact of Exoskeletons on Performance and Safety of Construction Workers
- 08 Federated Platform for Construction Simulation
- 09 Industrialization and Decarbonization of the Construction Process
- 10 Robotic wall construction using innovative building blocks and processes for enhanced productivity, safety, and sustainability.
- 11 Practical Methods for Accurate Estimation of Overall R-Values of Masonry Walls
- 12 Structural Steel Project Development Integrating Structural Design and Construction Engineering: Quantitative Methods and AI-based Tools

CIC-approved Projects

- 13 An Open Platform for Predicting Energy Performance of Buildings: Accelerating Energy Code Adoption
- 14 Driving Change Toward a Wider Adoption of Collaborative Delivery Methods in Canada
- 15 EEG-based Cognitive Monitoring Framework to Prevent Operators Cognitive Failure for Construction Safety and Productivity
- 16 Fast and Flexible Manufacturing of Industrial-Size Components Using Weld-Based Additive Manufacturing
- 17 Performance-targeted Hybrid Multistory Buildings for Resilient and Sustainable Construction

BY THE NUMBERS

PROJECT STATS

17

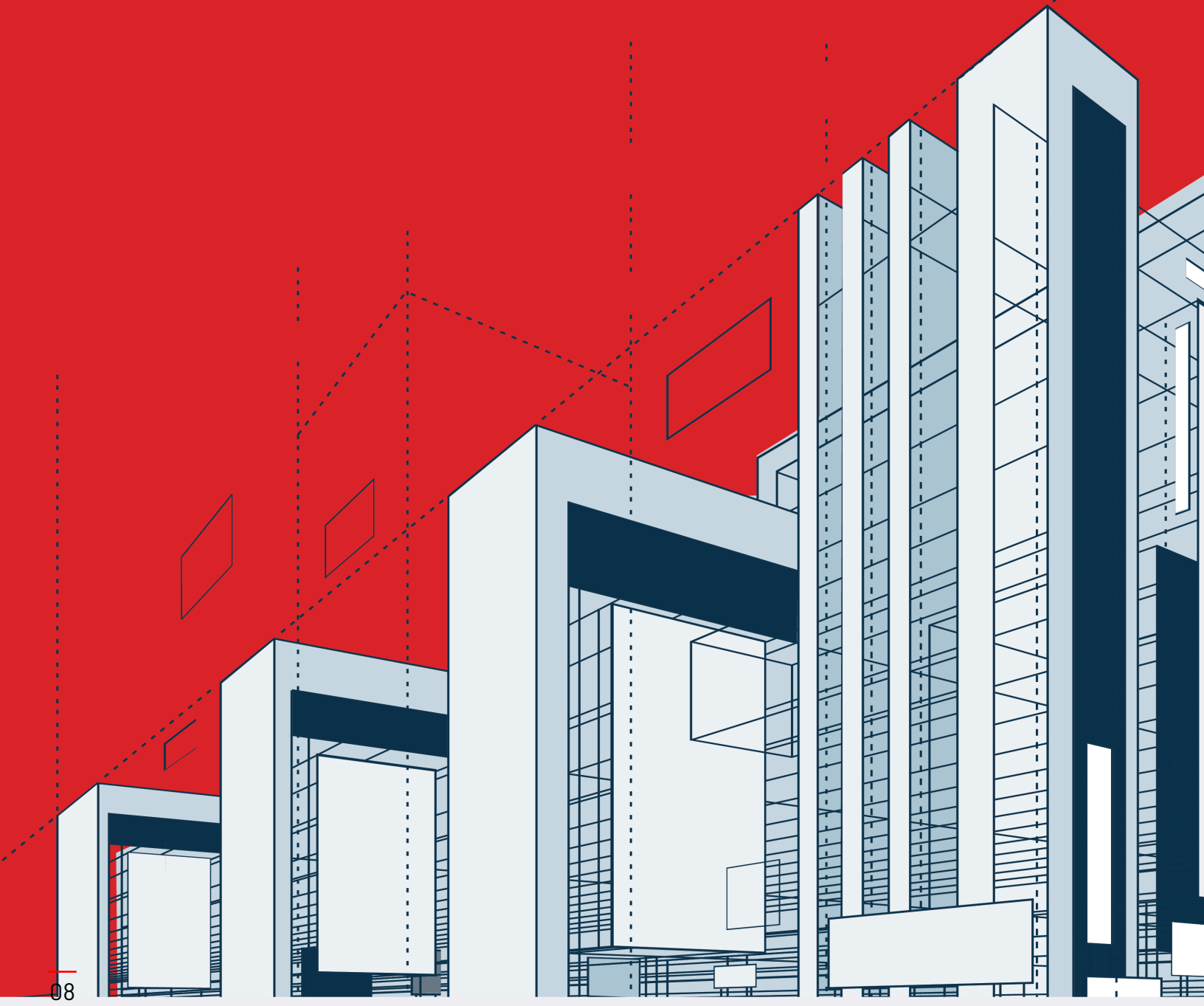
**APPROVED
PROJECTS**

36

**ACADEMIC
RESEARCHERS**

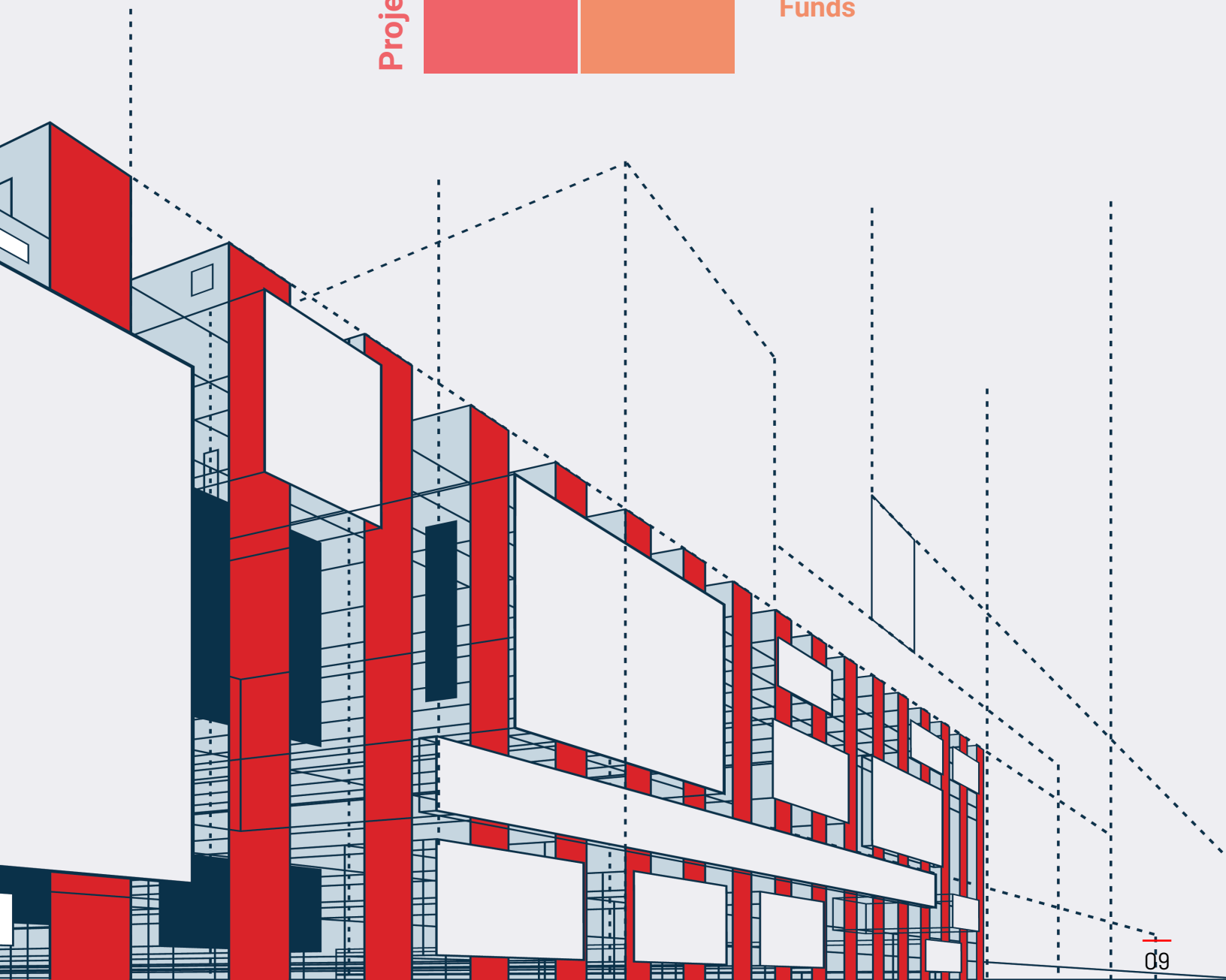
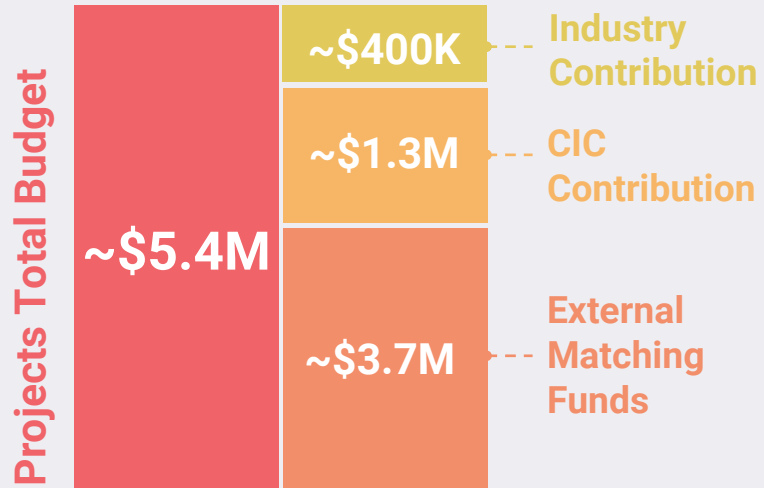
50

**INDUSTRY
PARTNERS**



BY THE NUMBERS

PROJECT STATS



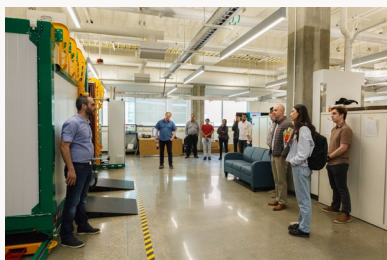
ACTIVITIES

CIC EVENTS

CIC Open House

April 2023

The CIC welcomed industry professionals and researchers to the CIC's labs, where visitors participated in discussions and demonstrations of current research innovations. Attendees explored projects at the CIC's Biosensors, Exoskeletons, and Robotics Arms Lab; the Canadian Centre for Welding and Joining; the Masonry Centre; the Networked Optimization, Diagnosis, and Estimation (NODE) Laboratory; the Smart and Sustainable Manufacturing Systems LABORatory; and the Steel Centre.





Webinar: Digital Twins in Construction

January 2023

The CIC organized this webinar in collaboration with the Off-site Construction Research Centre (OCRC) at the University of New Brunswick and the Centre for Innovation in Construction and Infrastructure Engineering and Management (CICIEM) at Concordia University. The webinar included three presentations: “Do We Need Digital Twins?”, presented by Mark Cichy, Director of Design and Technology at HOK; “How Digital Twins Can Help Drive Efficiency in the AEC Industry”, by Bhargav Dave, Founder and CEO of VisiLean; and “Structural Digital Twin for Bridge Infrastructure” by Kamyab Zandi, Founding Director of Timezyx.

Online Seminar

Digital Twins in Construction

January 26, 2023
10-11:30 am MST,
12-1:30 pm EST,
1-2:30 pm AST

Mark Cichy
Director of Design Technology
HOK

Bhargav Dave
Founder and CEO
VisiLean

Kamyab Zandi
Founding Director
Timezyx

CIC CONSTRUCTION INNOVATION CENTRE
Research Driving Change

UNIVERSITY OF CONCORDIA
Concordia

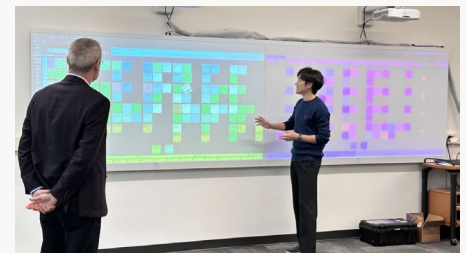
CICIEM
CENTRE FOR INNOVATION IN CONSTRUCTION AND INFRASTRUCTURE ENGINEERING AND MANAGEMENT

UNB Off-site Construction Research Centre

U of A President, VPRI, and Dean of Engineering Visit to the CIC Labs

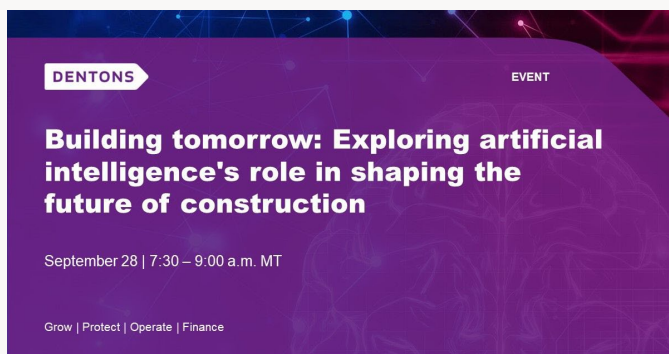
November 2023

The University of Alberta’s President and Vice-Chancellor, Bill Flanagan, was joined by the Vice-President of Research and Innovation, Dr. Aminah Robinson Fayek, and the Dean of the Faculty of Engineering, Dr. Simaan AbouRizk, for an in-depth look at some of the CIC’s ongoing projects. During the tours of the CIC lab, the Nasser School of Building Science Lab, and the I. F. Morrison Structures Lab, researchers presented their work on exoskeletons for construction workers, biosensors used to improve safety and productivity on construction sites, virtual reality environments and digital twins, construction robotic applications, an environmental chamber for material testing, 3D printing for construction, and large-scale electro-hydraulic testing.



Building Tomorrow: Exploring AI’s Role in Shaping the Future of Construction

September 2023



Dentons law firm hosted a discussion about the transformative impact of Artificial Intelligence on the construction industry from legal, academic, and industry perspectives. Speakers included Alexis Barr-Gusa and Simon Elzen-Hoskyn, both Partners at Dentons; Qipei Mei, Assistant Professor of Civil and Environmental Engineering at the University of Alberta; and Rob Swynar, Founder and CEO of Xkey AI Estimation.

Discussion topics ranged from document production management to AI in engineering design and maintenance, and participants took an in-depth look at case studies of AI implementation.



EVENTS

CIC Forum 2023

The CIC annual forum provides a platform to share the most recent advancements in construction innovation and to form collaborations among innovators, researchers, and construction professionals. This year's attendees participated in networking events, presentations of the CIC's current research projects, a Lean Construction 4.0 workshop, and panels on safety and sustainability.

Keynote speakers also included representatives from the Integrated Project Delivery Alliance, Alberta Infrastructure, Alberta Innovates, and who spoke about the future of construction in Alberta.



Construction Innovation Centre Forum

Innovation and Collaboration for Smart Sustainable Construction



 **July 27-28**
 **UofA Campus**

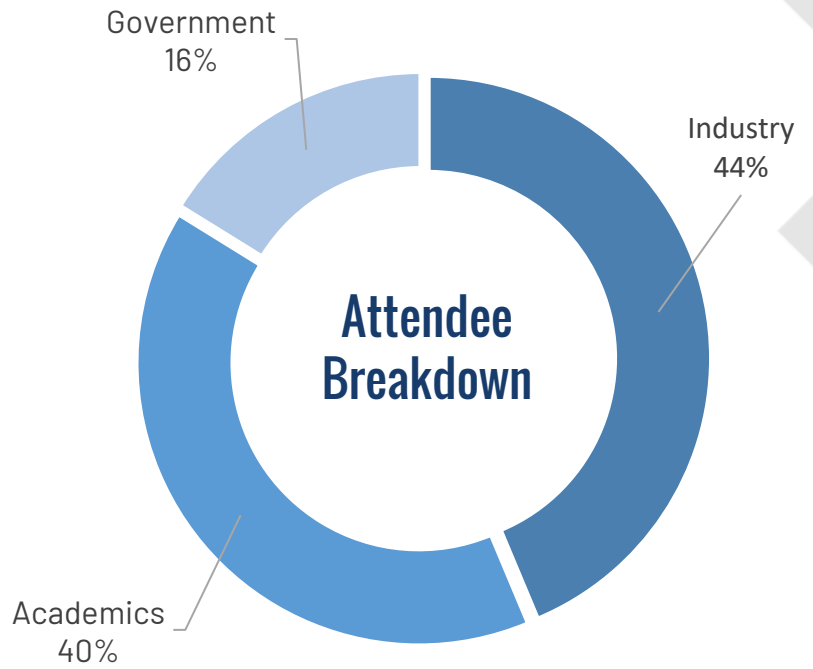


EVENTS

CIC Forum 2023

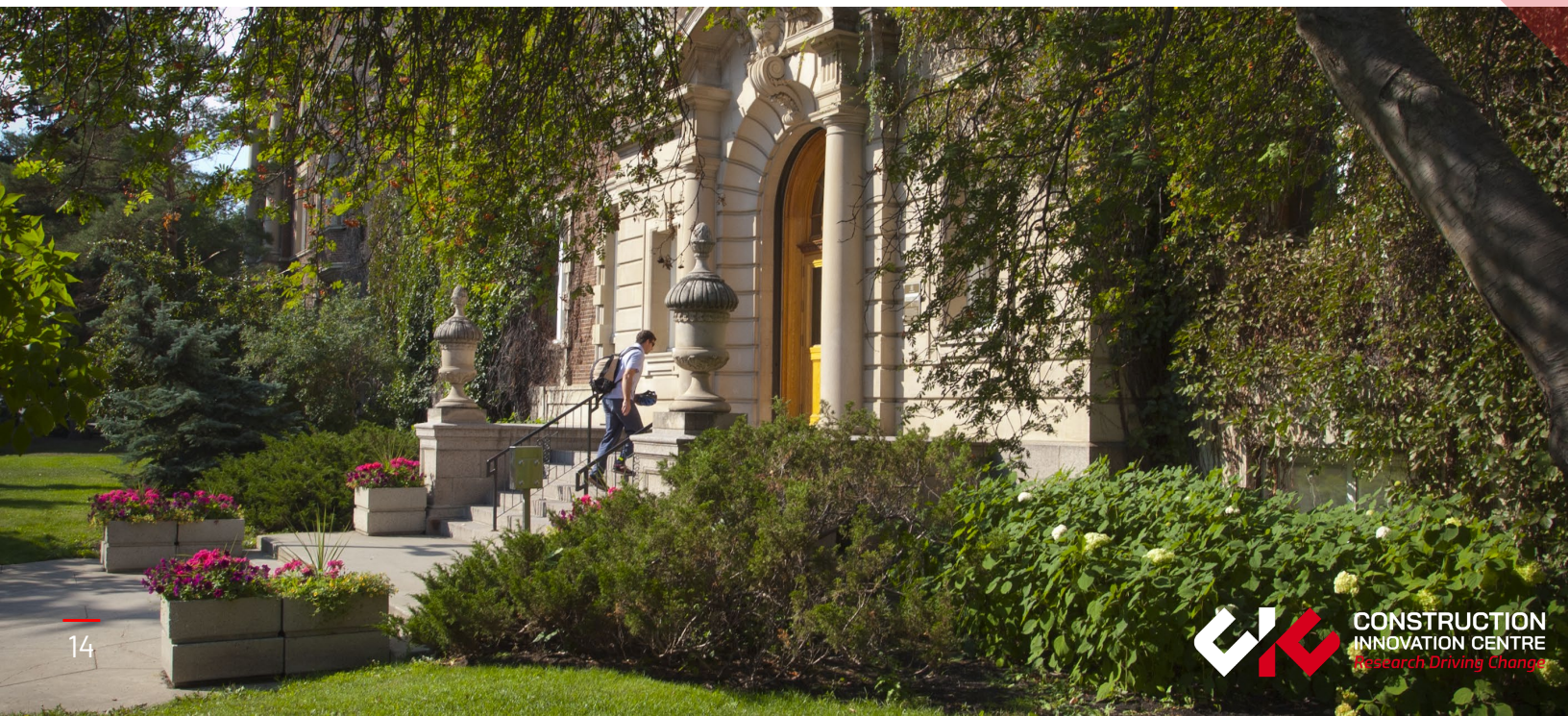
158
Total Registrants

143	131
Day 1	Day 2



59

of students attending



OUTREACH

Articles & Publications

The University of Alberta's Construction Innovation Centre

- By Ali Golabchi. *Breaking Ground, Edmonton Construction Association*. Summer 2023

The University of Alberta's Construction Innovation Centre (CIC): Academia-Industry Collaboration for High-Impact Research

- By Ali Golabchi, Yasser Mohamed, Aminah Robinson Fayek, & Simaan AbouRizk. *Construction Research Congress (CRC) Conference*. March 2024

Robotics for the Construction Industry – Is It Finally Time?

- By Ali Golabchi. *We Build: Saskatchewan's Construction Magazine*. Spring 2023

Exoskeletons: Will They Become a More Common Sight on Construction Sites?

- Featuring an interview with Ali Golabchi, highlighting the CIC and the exoskeleton project. *Construction Technology: Innovations in Reshaping the Construction Industry*. May 2023

AI in Construction: An Effective Tool in Trained Hands

- Featuring interviews with Ali Golabchi and three CIC researchers. Written by Jay Summach from amii. *Breaking Ground, Edmonton Construction Association*. Summer 2023



AI IN CONSTRUCTION
An effective tool in trained hands

By Jay Summach, Key Account Manager, Amii (Alberta Machine Intelligence Institute)

Every 10 seconds, a new story makes the rounds about a computer doing things that nobody expected a non-human to be able to do... not in 2023, at least. At the same time, it's the self-driving cars and computers winning game shows, from the conventional level playing boards to large language models like ChatGPT and the mind-boggling range of home, school, and work tasks that they seem to be taking from human-to-do lists.

From 2005 to 2023, I served the ECA as director of education. During that time, I got to know hundreds of Edmonton-area companies that deliver world-class construction services and products. Our city has played a prominent role in the evolution of the global architecture, engineering, and construction (AEC) industry over the last 20 years – and that's evident in the high number of international companies that originated and continue to be headquartered here.

Today, in an account manager with Amii, the Alberta Machine Intelligence Institute. To the same extent that Edmonton is a construction town, Edmonton is an artificial intelligence town. Amii started 20 years ago with four founding researchers at the University of Alberta. Since its partnership with investment from the governments, Amii, global governments. Today, Amii funds research through an incorporation of 75 AI machine learning startups. My purpose in this share will be to share the research and construction of Alberta's CIC and Amii's research and construction of Alberta's CIC.

Before I introduce you to some of the projects underway at the CIC, here's a short primer on what we mean by "artificial intelligence" and "machine learning".

ARTIFICIAL INTELLIGENCE (AI) AND MACHINE LEARNING (ML)

Artificial intelligence refers to technology that can do things that, formerly, only a human could do. A smart speaker can understand what you're saying, play the song you asked for, and follow it up with another song that you'll probably like. That's AI at work. AI is, in fact, most of our devices these days: it populates our social media feeds, it filters the ads from our phones, it suggests a better route to our destination, etc.

AI came together as a science over 70 years ago at the intersection of computer science, mathematics, and philosophy. In 1955, Alan Turing coined a catchier "Computing Machinery and Intelligence" in which he asks the question, "Can computers think?" His key intuition was that "Human intelligence comes from combining experience and reason and if a computer has access to experience (data), data and reason (algorithms) can be software, the computer ought to be able to 'imitate' human intelligence. Turing was right – and 70 years later, it's becoming clearer to distinguish the imitation from the real thing. Machine learning (ML) is a kind of AI.

Dr. Ali Golabchi is an active member of the research team at the University of Alberta's Construction Innovation Centre (CIC). He is a professor of civil and environmental engineering and a senior research advisor at the CIC. He is also a past president of the Society of Professional Engineers and Technicians (SPEAT) and a past president of the Society of Professional Engineers and Technicians (SPEAT). He is also a past president of the Society of Professional Engineers and Technicians (SPEAT).

78 Edmonton Construction Association

ROBOTICS FOR THE CONSTRUCTION INDUSTRY
IS IT FINALLY TIME?

By Ali Golabchi, Ph.D., PMP

Despite the large size of the construction industry and its contribution to the global economy, it is still one of the slowest to adopt emerging technologies, automation, and digitization. Among the rapidly evolving technologies of the 21st century, robotics is one that has the potential to mitigate some of the growing challenges of the industry. The significant productivity of construction, the ever-growing crisis of skilled labour shortage, the labour-intensive nature of construction jobs, the high rates of injuries, the sustainability challenges, and the need to deliver on projects faster and at lower costs all call for adoption of innovative technologies such as robotics.

Recent surveys also indicate an uptick in the interest of construction companies to adopt robotics.

21st century, robotics is one that has the potential to mitigate some of the growing challenges of the industry. The significant productivity of construction, the ever-growing crisis of skilled labour shortage, the labour-intensive nature of construction jobs, the high rates of injuries, the sustainability challenges, and the need to deliver on projects faster and at lower costs all call for adoption of innovative technologies such as robotics.

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BE MORE DISRUPTIVE
Push boundaries and redefine what's possible with AI. Drive down costs. Boost efficiency. Strengthen the core of your business. With AI, you and your business can be more.

amii.ca

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COLLABORATIONS

New CIC Partnerships



RESEARCH DRIVING CHANGE

INITIATIVES

CIC's Tech Transfer & Commercialization Focus Group

The CIC has initiated a new focus group called the Tech Transfer & Commercialization focus group, aiming to bring together members of the construction industry, academia, the startup community, and government and funding bodies with the goal of supporting the transfer and commercialization of research activities in the construction innovation ecosystem. The focus group will be composed of researchers, industry practitioners, entrepreneurs, innovators, investors, change agents, entrepreneurs, and students interested in advancing the adoption of innovation and technology in the construction industry.

Formation of the focus group was announced through the CIC's mailing list and more than 40 people have registered to attend. The first meeting will take place in the first quarter of 2024.

CIC Members



CIC Advisory Board and Team



Travis Chorney

Senior VP
PCL



Jim Kanerva

General Manager
Carry Steel



Simaan AbouRizk

Dean and Professor
University of Alberta



Reza Nasser

CEO
Landmark Group



John Singleton

Senior VP
Aecon



Quentin Huillery

Chief Operating Officer
Ledcor



Jamie Feuffel

Operations Manager
PCL



Chris Ambrozic

President
Scorpio Masonry



Steve Owens

Vice President, Construction
Capital Power



Tracy Hill

Executive Director
COAA



Samer Adeeb

Department Chair
University of Alberta



Rod Wales

Vice President
Ledcor



Ben Gillam

Division Manager
Scorpio Masonry



Anastasia Elias

Associate Dean
University of Alberta



Haitao Yu

Lead, R&D
Landmark Group



Brad Heintz

Senior Manager
Capital Power



Rob Wright

Vice President, Operations
Collins Industries



Yasser Mohamed

Director
Construction Innovation Centre



Ali Golabchi

Associate Director
Construction Innovation Centre



Amanda Peters

Strategic Support Coordinator
Construction Innovation Centre



Brann Munro

Technical Writer
Construction Innovation Centre

CIC Project Spotlight

CONSTRUCTION-ORIENTED DIGITAL TWINS FOR MULTI-DIMENSIONAL PROJECT PLANNING AND CONTROL

Duration: 5 years
Budget: \$495,000/year

The aim of this research is to develop a multi-dimensional approach to construction planning and control that simultaneously addresses multiple focus areas of construction management, and provides seamless integration of as-built data with project plans.

Industry Challenge

Process methodologies across the different focus areas of construction management (cost, schedule, quality, resources, risk, safety) tend to be incompatible, and the limitations of current planning practices often lead to ineffective project performance forecasting and unachievable plans. The successful implementation of advanced strategies like Industry 4.0 requires the successful integration and analysis of data across multiple focus areas.

Research Approach

Using the techniques of digital twin technology and Industry 4.0, CIC researchers seek to improve the collection of sensor-based, real-time, as-built project data, and to enhance synchronization of that data with original project plans. Research activities will run in parallel, each focusing on data collection and the development of a deliverable standalone solution to a specific planning and control challenge (such as Takt schedule compliance, work-package risk assessment, and waste reduction). These solutions will later be integrated into a larger **multi-dimensional framework to improve decision-making and project control and forecasting.**



Aminah Robinson Fayek



Farook Hamzeh



Ming Lu



Yasser Mohamed



Simaan AbouRizk

Deliverables

Deliverables will include six combinable decision-support frameworks and an integrated multi-dimensional approach for enhanced construction planning and control. Training materials, user manuals, technical summaries, installation manuals, and training sessions will also be developed and provided as needed.



CIC Project Spotlight

ENHANCING SAFETY MANAGEMENT SYSTEMS PRACTICES ON CONSTRUCTION PROJECTS: A PROACTIVE DATA-DRIVEN APPROACH

Duration: 3 years
Budget: \$300,000/year

The goal of this project is to develop a new framework for safety management that integrates quantitative and qualitative data across multiple areas, enabling robust holistic planning for safety that is based on project progress and historical data.

Industry Challenge

Safety management systems traditionally function independently from other project management systems, so it can be difficult for organizations to identify how other management decisions may affect the safety of workers. This lack of integrated safety management often results in a failure to adequately identify behavioral factors that may drive safety performance, a limited ability to evaluate multiple performance metrics or account for their interrelationships, and a focus on lagging indicators.

Research Approach

Using project data from a wide variety of sources (e.g., such as management decisions related to project planning control, job and site conditions, safety performance records) researchers aim to develop simulation models to predict and evaluate the impact of different management decisions on safety performance. Some of the research objectives include **automating safety hazard identification for each work package, using leading indicators in project safety assessments, and integrating safety management with other management systems.**



Lianne Lefsrud



Yasser Mohamed



Aminah Robinson Fayek



Simaan AbouRizk



Lisa White

Deliverables

The successful implementation of an integrated model that combines big data analytics, artificial intelligence, and simulation will assist construction organizations to proactively measure and control safety on construction projects, facilitating the development of more effective policies and improving safety performance.



CIC Project Spotlight

EVALUATION OF IMPACT OF EXOSKELETONS ON PERFORMANCE AND SAFETY OF CONSTRUCTION WORKERS

Duration: 3 years
Budget: \$105,000/year

Researchers are evaluating the suitability of exoskeletons to reduce injury in physically demanding construction tasks, and working to develop a systematic framework for the selection and implementation of exoskeletons in the construction industry.

Industry Challenge

Repetitive strain and musculoskeletal injuries make up a significant portion of disabling injury claims in construction. Exoskeletons (body-worn devices that reduce physical strain during certain tasks) are emerging as a possible solution; however, given the dynamic nature of construction tasks, the many hazards of construction worksites, and the lack of studies on construction-specific applications of exoskeletons, it is unclear how they could be safely and effectively implemented in the industry.

Research Approach

In collaboration with industry partners, CIC researchers have developed research activities to investigate the **impact and efficacy of employing exoskeletons in construction tasks**. Using inertial measurement units, motion-capture systems, and biosensors, CIC researchers simulate the tasks that cause the most frequent and debilitating injuries. Then, analyzing the biomechanics and kinematics of the worker's body, measuring fatigue, and evaluating task performance, researchers will **develop and test exoskeleton solutions that improve construction safety while improving productivity**.



Hossein Rouhani



Mahdi Tavakoli



Ali Golabchi

Deliverables

This project will develop a systematic approach and decision-making framework for prescribing, adopting, and implementing industrial exoskeleton-based solutions on a job-specific basis. This research aims to improve profitability of industry partners by enhancing performance and reducing lost-time and insurance costs, while also directly improving quality of life for workers by reducing pain and injury.





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