June 2022

Insight report: Innovation & R&D in construction

Construction 4.0

In this issue:

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Construction 4.0

Construction 4.0 is a variety of interdisciplinary technologies that digitize, automate and integrate the construction process at all stages of the value chain.[1]

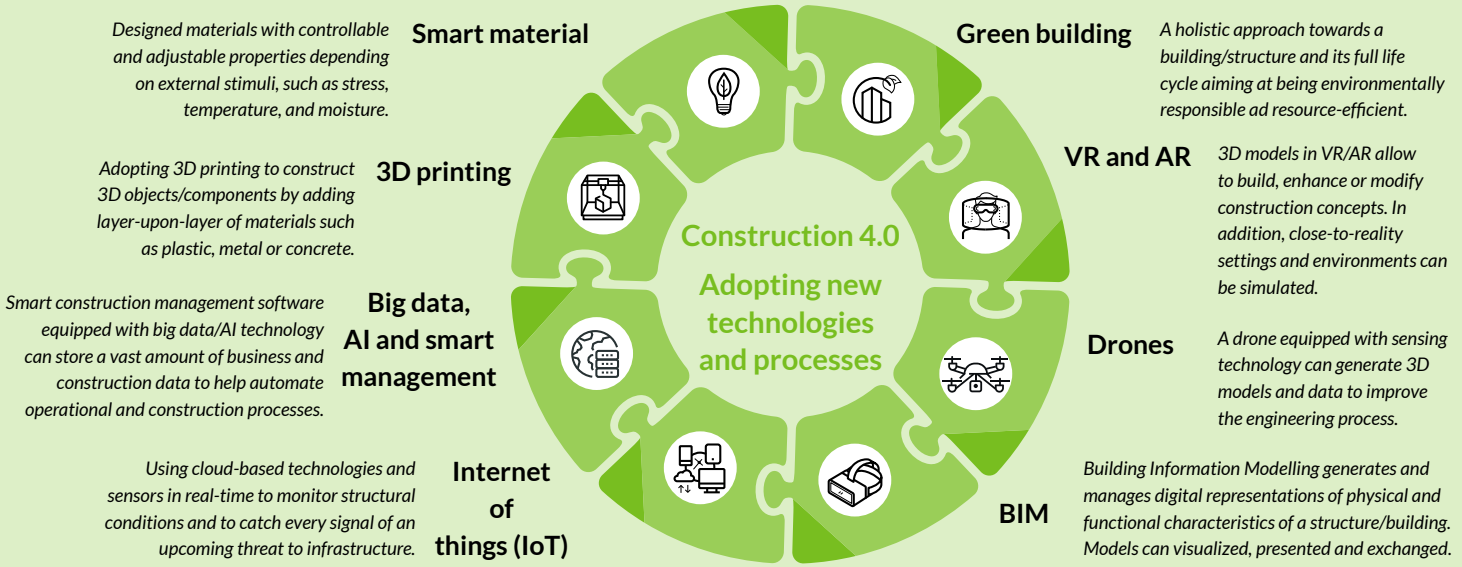
While the definitive definition of construction 4.0 is still being determined, this edition of the *Insight report: Innovation and R&D in construction* will focus on the following areas:

Sustainability and smart/green building

Big data, smart management and AI

AR, VR and digital twins

Learn how each issue relates to construction. Explore the research that is being done by our universities. See how our industry is responding. Get connected to resources that can help you foster innovation at your own business.



Definitions by Startus insights

1 Oesterreich, T.D.; Teuteberg, F. Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. Comput. Ind. 2016, 83, 121–139.

1.1

Construction research at your fingertips

CCA and Cognit.ca launched the first ever Construction R&D Portal to help you navigate through the vast amount of research on construction within our university network.

$14 billion of research performed by universities annually

100,000+ experts and research documents

225,000 research grants

Data provided is from the cognit.ca tool and is for illustrative purposes. Searches may yield different results depending on key words used and the time the search was effected.

The Canadian Construction Association (CCA) is the national advocate for the industry, ensuring fair and transparent procurement, consistent and sufficient investment in infrastructure, and attracting a skilled workforce.

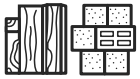
Our mission is to “inspire a progressive, innovative and sustainable construction industry that consistently acts with integrity”. Our 20,000 members take great pride in the work they do to build strong, resilient and caring communities across Canada.

2

Sustainability and smart/green materials

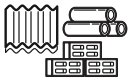
2 Sustainability and smart/green materials

Current state of the industry:



Global material use is expected to more than double by 2060, with a third of this rise attributable to materials used in the buildings and construction sector among rapidly growing populations and economically developing countries[2].

By 2025, it is expected that 2.2 billion tonnes of construction waste will be generated around the world, nearly double the amount of waste in 2018[3].



Only three materials – concrete, steel and aluminum – are responsible for 23 per cent of total global emissions[4].

It is estimated that embodied carbon will be responsible for almost half of total new construction emissions between now and 2050[5].

Globally, there is a growing demand for more buildings and floor area, with the floor area of the global buildings sector projected to double by 2060[6].

2 Organisation for Economic Co-operation and Development [OECD], 2019.

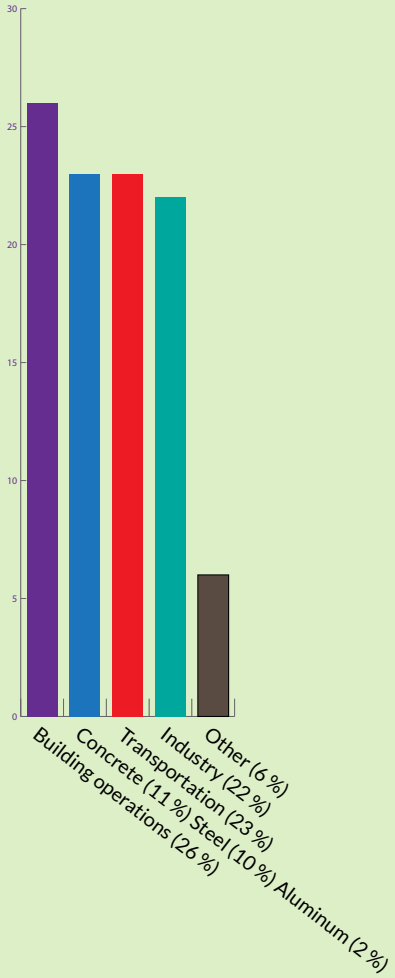
3 Ellen Macarthur Foundation, Building a world free from waste and pollution (ellenmacarthurfoundation.org)

4 Embodied Carbon Actions – Architecture 2030

5 New Buildings: Embodied Carbon – Architecture 2030

6 United Nations Environment Programme (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zero emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

Annual global CO_2 emissions



Where are green materials being used in the industry?

- Currently, the market demand for green materials varies depending on the geographic location in Canada.
- Key drivers behind the movement towards using greener material methods, such as deconstruction and resource recovery, include supply chain and material price volatility[7].
- Sustainable concrete – The industry is slowly substituting general-use concrete with materials with lower carbon footprints, such as Portland limestone concrete.
- Mass timber – The industry is replacing metal and solid wood components with cross-laminated-timber beams and mass timber panels, both in homes and multi-storey buildings.
- Prefabricated buildings – These buildings avoid labour overruns, weather delays and reduces material waste.

What are the benefits of using smart green materials, sustainable construction?

- A study found that energy management has the greatest effect on economic performance when compared to other green site practices. Energy efficiency during the construction process is given little attention compared to that given during occupancy and operations of a building[8].
- A life cycle assessment revealed that using a mass timber construction system in an eight-storey building reduced emissions by 20 per cent from an equivalent building over a 60-year lifecycle[9].
- By using cross-laminated timber instead of concrete for the construction of commercial buildings, a life cycle assessment shows that a potential 26.5 per cent reduction in global warming potential can be achieved[10].
- Companies active in green building construction and trades account for the largest percentage (46 per cent) of Canada's green building employment[11].
- Green building construction jobs represent about 17 per cent of Canada's total construction workforce[8].

Between 2014 and 2020, the green building industry has grown by 55 per cent[8].

7 Circular Economy and the Built Environment Sector in Canada. The Delphi Group, 2021.

8 Hilary Omatule Onubi, Nor'Aini Yusof and Ahmad Sanusi Hassan. Effects of green construction on project's economic performance.

9 Building with wood: A big piece in the puzzle of decarbonizing the economy by 2050.

10 Francesca Pierobon, Monica Huang, Kathrina Simonen, Indroneil Ganguly, Environmental benefits of using hybrid CLT structure in midrise non-residential construction: An LCA based comparative case study in the U.S. Pacific Northwest, Journal of Building Engineering, Volume 26, 2019.

11 Canada's Green Building Engine, Market Impact and Opportunities in a Critical Decade.

2.1

To learn more about each project, click on the title.

Examples of projects on the Construction R&D portal **Sustainability**

Smart Irrigation Control Systems for Productive Green Roofs

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Engage Grants Program
- Year: 2019/20
- Total Funding: $25,000

Keywords
- Environment
- Environmental engineering
- Environmental impact of economic activities (including agriculture)

Principle Investigator(s)
- ValterMai, Kristiina
  Ryerson University

Carbon Negative Buildings for Sustainable Construction: Structural Performance of Hybrid Timber and Concrete Columns

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2012/13 to 2016/17
- Total Funding: $105,000

Keywords
- Construction, urban and rural planning
- Structural engineering
- Structural materials

Principle Investigator(s)
- MacDougall, Colin
  Queen's University

Advancing energy recovery from source-diverted municipal wastewater: shaping microbial community through direct interspecies electron transfer

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Strategic Projects - Group
- Year: 2019/20
- Total Funding: $198,000

Keywords
- Commercial services
- Environmental engineering
- Waste, waste management and recycling
- Waste water treatment

Principle Investigator(s)
- Liu, Yang
  University of Alberta

Information Technology for Sustainable Infrastructure Construction and Management

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2015/16 to 2019/20
- Total Funding: $125,000

Keywords
- Civil engineering
- Construction engineering and management
- Construction methods
- Construction, urban and rural planning

Principle Investigator(s)
- Haas, Carl
  University of Waterloo

Examples of projects on the Construction R&D portal **Smart materials**

Development of Damage-Resislient Structures Using Smart Materials

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2017/18 to 2019/20
- Total Funding: $84,000

Keywords
- Civil engineering
- Construction engineering and management
- Construction, urban and rural planning

Principle Investigator(s)
- Palermo, Dan
  York University

Strengthening Concrete Structures with Smart Materials

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2015/16 to 2019/20
- Total Funding: $110,000

Keywords
- Civil engineering
- Construction, urban and rural planning
- Structural engineering

Principle Investigator(s)
- ElHacha, Raafat
  University of Calgary

4D Smart Materials: A Hierarchical Manufacturing Platform

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2018/19 to 2019/20
- Total Funding: $128,000

Keywords
- Advanced manufacturing
- Design and manufacturing
- Manufacturing processes and products

Principle Investigator(s)
- Naguib, Hani
  University of Toronto

Use of crystalline waterproofing technology and SCMs to develop sustainable and smart self-sealing materials

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Collaborative Research and Development Grants
- Years: 2014/15 to 2016/17
- Total Funding: $71,200

Keywords
- Civil engineering
- Construction, urban and rural planning
- Materials performance

Principle Investigator(s)
- Gupta, Rishi
  University of Victoria

Examples of projects on the Construction R&D portal **Green materials**

To learn more about each project, click on the title.

Developing sustainable nanoparticles for reinforcement of next generation green materials and composites

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Collaborative Research and Development Grants
- Year: 2019/20
- Total Funding: $75,000

Keywords

- Construction, urban and rural planning
- Materials performance
- Materials science and technology
- Materials structure, properties and testing

Principle Investigator(s)

- Naguib, Hani
  University of Toronto

Guidelines development for sustainable use of reactive/ marginal/recycled aggregates in concrete construction

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Discovery Grants Program - Individual
- Years: 2018/19 to 2019/20
- Total Funding: $72,000

Keywords

- Civil engineering
- Construction engineering and management
- Engineering

Principle Investigator(s)

- Fournier, Benoit
  Laval University

Novel Green Concrete Components for Modular Construction

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Discovery Grants Program - Individual
- Years: 2017/18 to 2019/20
- Total Funding: $123,000

Keywords

- Construction, urban and rural planning
- Materials performance
- Materials science and technology
- Materials structure, properties and testing

Principle Investigator(s)

- Lachemi, Mohamed
  Ryerson University

Phase II: Manufacturing of 'Green' innovative bath tubs using hybrid cementitious materials and left over acrylic to achieve Zero Waste

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Engage Plus Grants Program
- Year: 2017/18
- Total Funding: $12,000

Keywords

- Civil engineering
- Manufacturing processes and products

Principle Investigator(s)

- Gupta, Rishi
  University of Victoria

Collaborator(s)

No researchers found.

Companies active in green building construction and trades account for

46 %

of Canada's green building employment

Green building industry has grown by

55 %

2.2

Two firms take home CCA's Environmental Achievement Award

The effects of climate change being witnessed are reinforcing the need to improve our practices and build more sustainability into our projects. This year, CCA recognized two recipients for this award – one that highlights the overall efforts to effect change within an organization, and one that spotlights the benefits of environmental considerations.

The information provided is taken from the awards submissions of EllisDon and PCL, as agreed upon during the submission process.

Sustainability, green building and smart building – what is happening within the CCA family

How sustainability is embedded into and informs everything done at EllisDon

Watch EllisDon's Environmental Achievement video from the CCA Annual Conference (3 minutes)

In 2021, EllisDon signed on to the Science Based Targets initiative (SBTi), committing itself to set verifiable science-based targets by 2023.

It's climate commitment focuses on these three core areas:

- Driving to zero emissions across its business operations
- Driving to zero emissions in materials procured for all projects it builds
- Driving to zero emissions in the operational performance of the projects it builds

Examples of actions already taken under the commitment:

- Piloting the collection of Scope 3 (supply chain and operational) emissions on select projects, including fuel use from sub-contractors and deliveries, embodied emissions associated with all major structural materials, and projected energy performance of buildings, with a view to requiring that all new projects measure and report this information by the end of 2022.
- Collecting the data from our owned assets and operations, including the emissions from its site operations across the country.

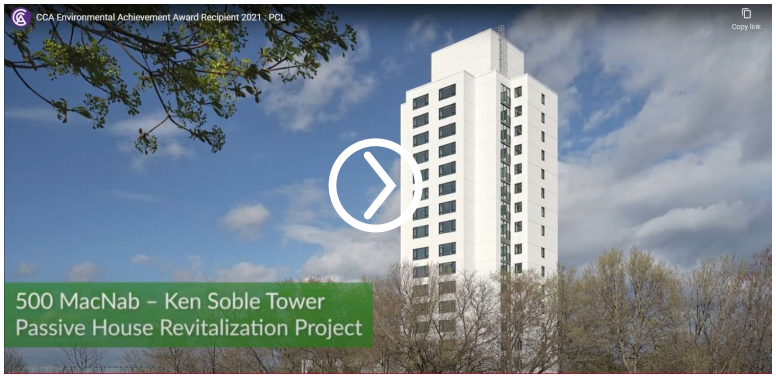
- Voluntarily reducing Scope 3 emissions on projects, identifying opportunities to do so without impacting schedule or increasing cost. For example, on the Royal Columbian Hospital project, EllisDon was able to reduce emissions from concrete supply by 20 per cent, approximately equivalent to 13.3 million km driven in an average passenger vehicle. (Learn more about this project)
- Supporting clients through preconstruction to identify opportunities to make lower carbon and better life cycle choices by providing an understanding of both the costs and benefits.
- Engaging and collaborating with concrete, steel and timber suppliers, including working with industry associations to standardize and develop Environmental Product Declarations (EFDs), to promote better transparency and identify opportunities for reduction.

EllisDon has committed to publicly sharing their progress by reporting on their Scope 1, 2 and 3 emissions on an annual basis and sharing lessons learned to drive innovation and change across the industry.

PCL — meeting rigorous Passive House standards

Considered North America's first EnerPHit retrofit of an apartment tower, and one of the largest EnerPHit projects in the world, PCL's 500 MacNab – Ken Soble Tower project is one of the first retrofits in North America to achieve certification under Passive House's internationally recognized EnerPHit program for buildings that meet ultra-low energy standards.

Watch PCL's Environmental Achievement video from the CCA Annual Conference (3 minutes)



Key passive house requirements and how they were met

Requirement	Solutions
High level of insulation in opaque wall and roof systems	• 152 millimeters of mineral wool insulation was installed on the existing exterior face masonry. An additional 100 millimeters of foil-faced mineral wool insulation was added to the walls' interior. The resulting U-value for the opaque areas of the exterior walls was approximately 0.13W/m^2k. • The new roof system consisted of 400 millimeters of insulation installed in an inverted configuration with a resulting U-value of 0.074 W/m^2k.
Well-insulated glazing assemblies	• Triple-glazed Cascadia fiberglass windows were used. They had an estimated U-value of 1 W/m^2k.
Thermal bridge-free design and construction	• Attempts were made to eliminate or minimize the thermal bridging. Examples include removal of all existing balconies, fiberglass angles to support the windows, PVC through wall flashings, and thermally insulation fasteners.
Airtight building envelope	• A continuous air barrier was installed on all the building envelope surfaces to meet the 0.6 ACH requirement. • On opaque wall areas, a cement air barrier and a moisture barrier were installed on the existing masonry prior to the installation of the EIFS cladding. • Silicone transition strips created continuity between the fiberglass windows and the opaque wall air barrier. The waterproofing and roof membranes were both continuously sealed to the wall air barriers. • Although penetrations through the envelope were kept to an absolute minimum, care was taken to ensure continuity of the air barrier at all locations.

The end result, a successful retro-fit that not only prevented the structure materials from going to the landfill but improved the operational efficiency of the building and its ability to withstand extreme climate events. As of result of the retrofit, thermal energy demand intensity was decreased by 89 per cent while greenhouse gas emissions were reduced by 94 per cent.

Learn more about the contractor's perspective on this project.

3 Big data, AI and smart management

3

Big data, AI and smart management

Current state of the industry:

The majority of Canadian construction companies rate their digital maturity as fairly low and are not leveraging technological adoption or are merely experimental[12].

McKinsey estimates that 98 per cent of megaprojects suffer costs overruns of more than 30 per cent. And 77 per cent are at least 40 per cent delayed[13].

From 2014 to 2019, the global construction industry has invested USD 26 billion into engineering and construction technologies, including AI, up from USD 8 billion over the previous five years[14].

Recent publications on construction 4.0 in the construction industry reflect the rapid growth of interest in the adoption of big data, AI and smart management in the construction processes. After reviewing more than 1000 articles since 2014, 49 per cent of select publications referencing these new technologies were published in 2020[15].

According to a survey of 400 global construction-industry experts, more than two-thirds of respondents expect changes due to technological adoption to happen in the next five years[16].

12 Construction in a digital world: a deep dive into technological adoption in Canada's construction industry, KPMG-CCA, 2021.

13 The construction productivity imperative | McKinsey.

14 Young, D.; Panthi, K.; Noor, O. Challenges involved in adopting BIM on the construction jobsite. Built Environ. 2021, 3, 302–310.

15 Maria Kozlovska, Daria Klosova and Zuzana Strukova. Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review.

16 McKinsey and Company. The next normal in construction: How disruption is reshaping the world's largest ecosystem.

Where is big data, AI and smart management being used?

Planning phase	Design phase	Construction phase
Automated project schedule	Building Information Modeling (BIM)	Construction modeling
Data accessibility	Internet-of-Things (IoT)	Image processing
Determine risks using predictive modeling	Generative design	Modular construction
Prevent costs overruns	Visualization	Autonomous vehicles
Health and safety	Clash detection	Autonomous excavation
Labour shortages and low productivity	Surveying	Task-specific robots
		Smart wearable technologies
		Robot equipment
		VR modeling

Benefits of using big data, AI and smart management

- The use of AI in construction has the potential to raise productivity from 0.8 to 1.4 per cent annually[17].
- Through real-time analysis of data, construction firms could increase their productivity by 50 per cent[18].
- A study discovered a significant negative relationship between the degree of adoption of big data and material and project delivery times using an econometric model. Adopting big data reduces material delivery time, shortens construction project time, and reduces its cost[19].
- The productivity gains of implementing AI scheduling programs could cause an average of 16 per cent shorter duration of a job and lower labour costs by 11 per cent[20].
- A case study of a construction project found that the use of big data technologies reduced work times by 50 per cent, while costs were reduced by 52.36 per cent[21].

17 Vaquero, T.S.; Silva, J.R.; Beck, J.C. Post-design analysis for building and refining AI planning systems. Eng. Appl. Artif. Intell. 2013, 26, 1967–1979.

18 The Next Normal in Construction, McKinsey and Company (accessed on 30 April 2022).

19 Tomáš Mandičák, Peter Mésároš, Andrea Kanáliková and Matej Špak. Supply Chain Management and Big Data Concept Effects on Economic Sustainability of Building Design and Project Planning.

20 Skibniewski, M.J.; Zavadskas, E.K. Technology development in construction: A continuum from distant past into the future. J. Civ. Eng. Manag. 2013, 19, 136–147.

21 Moh Nur Sholeh, Shifa Fauziyah, Riqi Radian Khasani. Effect of Building Information Modeling (BIM) on reduced construction time-costs: a case study.

3.1

To learn more about each project, click on the title.

Examples of projects on the Construction R&D portal **Big data**

Integration of Remote Sensing Big Data into the Management and Design of Highway Infrastructures

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Year: 2019/20
- Total Funding: $31,000

Keywords
- Civil engineering
- Transportation engineering
- Transportation systems and services

Principle Investigator(s)
- ElBasyouny, Karim
  University of Alberta

Assessing the readiness of Canadian small and medium-sized enterprises to leverage Big Data analytics

Funding Details

Social Sciences and Humanities Research Council
- Grant type: Insight Grants
- Years: 2016/17 to 2019/20
- Total Funding: $119,000

Keywords
- ANALYTICS
- big data
- Canada
- framework
- Innovation, Industrial and Tech. Develop
- Innovation, Industrial and Technological Development
- Innovation, Industrial and Technological Development

Show more

Principle Investigator(s)
- Persaud, Ajax
  University of Ottawa

Data Exploitation and processing for multi-sensor radar big data

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Department of National Defence / NSERC Research Partnership
- Years: 2016/17 to 2019/20
- Total Funding: $320,000

Keywords
- Aerospace
- Digital signal processing
- Electrical and electronic engineering
- Transportation systems and services

Principle Investigator(s)
- Leung, Henry
  University of Calgary

Mining, Fusion and Modeling of Truck Big Data for the development of Agent-Based Microsimulation Models

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2017/18 to 2019/20
- Total Funding: $63,000

Keywords
- Civil engineering
- Transportation engineering
- Transportation systems and services

Principle Investigator(s)
- Maoh, Hanna
  University of Windsor

Examples of projects on the Construction R&D portal **AI**

Road Condition Monitoring Using Smart Sensing and Artificial Intelligence: A Review

Sensors, Vol. 22 (2022)

Keywords
- Chemical technology

Authors
- Eshta Ranyal
  Department of Civil and Environmental Engineering, Western University, London, ON N6A 3K7, Canada
- Ayan Sadhu
  Department of Civil and Environmental Engineering, Western University, London, ON N6A 3K7, Canada
- Kamal Jain
  Department of Civil Engineering, IIT Roorkee, Roorkee 247667, India

Cyber-Physical System Approach for Improving Productivity and Safety of Construction Projects

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Year: 2019/20
- Total Funding: $62,000

Keywords
- Civil engineering
- Construction engineering and management
- Construction, transportation and communications
- Northern development

Principle Investigator(s)
- Hammad, Amin
  Concordia University

3D Mobile Mapping Using Artificial Intelligence

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Collaborative Research and Development Grants
- Year: 2019/20
- Total Funding: $167,750

Keywords
- Civil engineering
- Construction, urban and rural planning
- Survey engineering and remote sensing
- Surveying and photogrammetry

Principle Investigator(s)
- Sohn, Gunho
  York University

Embedding AI in Smart Sensors

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Engage Grants Program
- Year: 2019/20
- Total Funding: $24,992

Keywords
- Computer vision
- Instrumentation technology
- Manufacturing processes and products
- Robotics

Principle Investigator(s)
- Ferrie, Frank
  McGill University

Examples of projects on the Construction R&D portal **Smart management**

To learn more about each project, click on the title.

Big data technologies reduced work times by

50 %

Big data technologies reduced costs by over

52 %

Intelligent decision making and knowledge management in engineering project management procedures

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Collaborative Research and Development Grants
- Years: 2016/17 to 2019/20
- Total Funding: $154,288

Keywords

- Civil engineering
- Construction engineering and management
- Information and communication services
- Information systems and technology

Principle Investigator(s)

- Mccabe, Brenda
  University of Toronto
- McCabe, Brenda
  University of Toronto

Automation in construction/project management

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Discovery Grants Program - Individual
- Years: 2015/16 to 2019/20
- Total Funding: $125,000

Keywords

- Civil engineering
- Construction engineering and management
- Construction methods
- Construction, urban and rural planning

Principle Investigator(s)

- Moselhi, Osama
  Concordia University

Smart Supply Chain Management via Data Driven Optimization

Funding Details

Natural Sciences and Engineering Research Council of Canada

- Grant type: Discovery Grants Program - Individual
- Year: 2019/20
- Total Funding: $43,000

Keywords

- Industrial engineering
- Manufacturing processes and products
- Operations management
- Production and operations management

Principle Investigator(s)

- Zhang, Guoqing
  University of Windsor

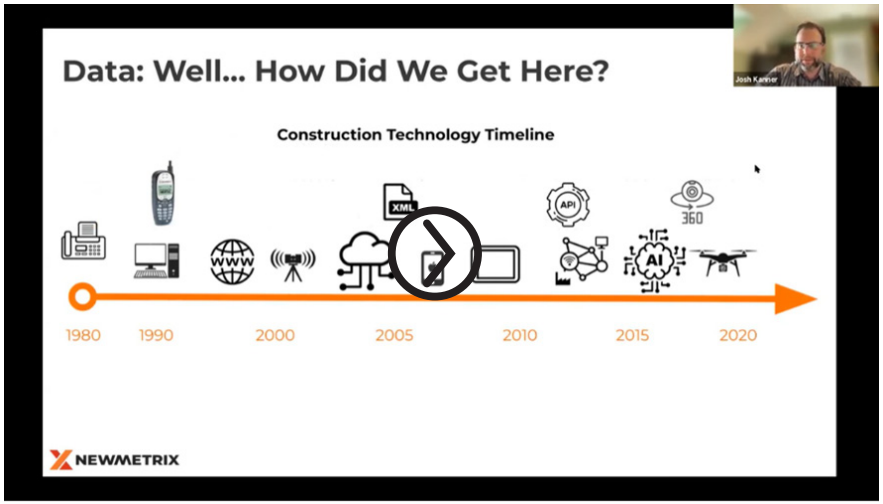
3.2

Big data, AI and smart management – what is happening within the CCA family

CCA's National Advisory Councils explore data sharing opportunities and challenges

CCA's five National Advisory Councils (NAC) met in November 2021 to discuss the benefits/challenges of sharing data. NAC members were provided with a video prepared by Newmetrix and the Predictive Analytics Council, as well as a construction data alliances briefing by AON.

An exploration of data trusts in construction presented by Newmetrix (30 minutes)



Council members were asked to consider:

1. Potential areas where data could help areas of their business;
2. What they would want in place to provide reassurance about sharing data; and
3. Options they thought merited further exploration.

To view a summary of the NAC council discussion, click here.

CCA Annual Conference: Data trusts: The next game changer for the construction industry?

Moderator David Bowcott, AON, and panelists Ian Dickinson of Graham and Mike Wieninger of PCL discussed their firms' approach to data trusts, and why they believe pooling data can help the industry address significant issues like health and safety, or improve productivity.

Established construction industry Data Trusts

Organization	Key members/participants		Purpose
Construction Data Trust	• Mace • Kier • Sir Robert McAlpine • Laing O'Rourke • Turner & Townsend • Murphy • Graham • Aon		Develop data trust framework and harness members data to help improve in following potential areas: safety, risk, quality, schedule, cost, resource & team, benefits & outcome, change, and commercial. **UK Based**
PREDICTIVE ANALYTICS STRATEGIC COUNCIL	• Suffolk • DPR • Skanska • Barton Malow • Bouygues • Mortenson • JE Dunn • Obayashi	• Messer • Webcor • Shawmut • Lithko • Aon	Harness various sources of data (focus on computer vision data) to improve safety outcomes by utilizing data to develop safety AI solution. Primary focus is safety, but other categories of operations data sharing are being considered. **North American Based**
PROJECTING SUCCESS	• Balfour Beatty • Kier • Mace • Microsoft • Ministry of Defense • Oil & Gas Authority • British Army • Osborne	• Oil & Gas Centre • PMO Learning • UiPath Partner • Baker Hughes • Sir Robert McAlpine • Project Management Institute	Projecting Success supports organizations to realize the transformational value of data, analytics, AI and Machine Learning in improving project delivery and develops leaders within your organization to make this possible. **UK Based**

Canadian Construction Association
Association canadienne de la construction

6

Ian Dickinson speaks to Graham's involvement with the Construction Safety Research Alliance. (3 minutes)

Points to ponder from the panelists

On sharing information

"I'm from the insurance sector, and it allows you to actually see the frequency and severity of events on a much grander scale. Some contractors or design firms may only have 10 to 15 claims a year, 20 claims a year, but when you aggregate everybody's claims together, you can actually see a much broader picture."

David Bowcott, AON

"Most recently, …over the last nine months, we got a peer group going on cyber security, where we share cyber security data with PCL, Bird, Aecon, other peers, and, already I think, that's been really valuable."

Ian Dickinson, Graham

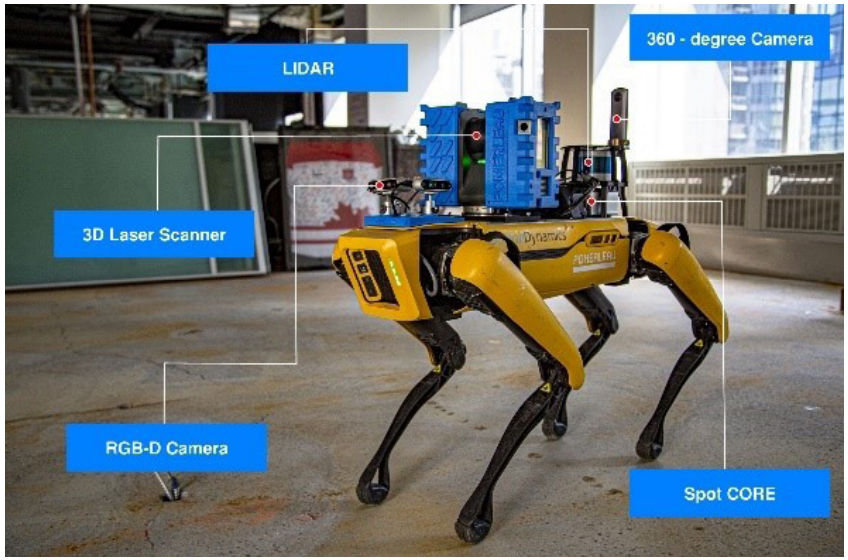
"For all of us, as an industry, and really any industry, (safety) is one part of the business that I think everybody's willing to share. The tough part becomes … the productivity or let's call it… company proprietary information - your secret sauce - what differentiates you and what makes you profitable. So, I think, from our perspective, that that's a hurdle to get over. What areas of information are you willing to share that doesn't compromise your organization or your success."

Mike Wieninger, PCL

Update from Pomerleau on SPOT the Dog

SPOT has been part of Pomerleau's family for over two years. The technology is primarily used for data collections on sites, enabling our workforce to focus on value-added tasks and enhance their productivity. Pomerleau has measured the effectiveness of SPOT for autonomous reality capture in terms of accuracy, time and cost. In addition to the capture of data by 360 photos, SPOT also uses its laser scan, introduced in late 2021 at Pomerleau.

Photo provided by Pomerleau



The 360 photos are used to monitor advancement of projects, comparing them to the initial models, automating a task that would previously take an employee walking the site several hours. Employees are now able to focus their time on analyzing the data and providing insights to the project team and client. The laser scan allows Pomerleau to collect point clouds and observe deviations from the model – improving the quality of the final project being delivered to the client.

Currently, SPOT still needs a supervisor on site to help it complete its tasks, however, Pomerleau is developing POMRCC (Pomerleau Robotic Command Centre) to remove the robot supervisor from the worksites and allow the individual to guide SPOT remotely.

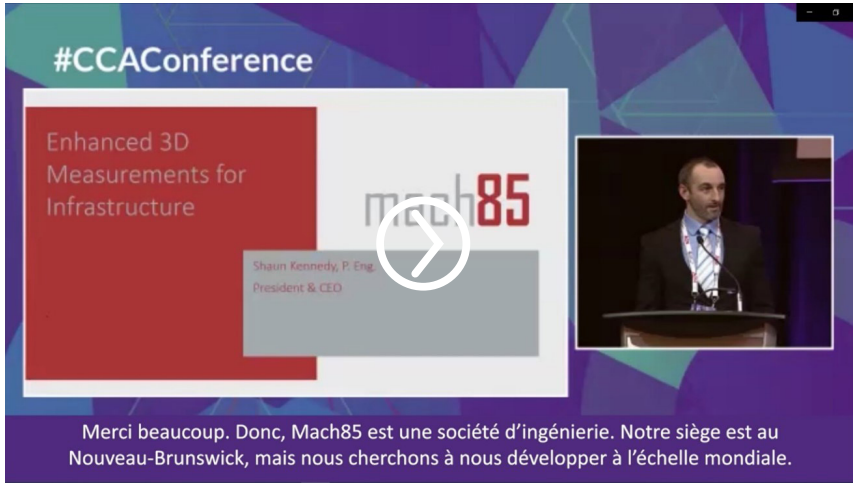
Learn more about SPOT's start with Pomerleau, and its technology.

CCA's CONtact mentorship program

Mach85: Winner of "The innovator's pitch: CONtact"

CCA asked – can you provide a snapshot of the benefits to your innovation?

- We allow for measurements to be taken everywhere - over entire surfaces as opposed to just taking a few measurements at locations where you think the worst-case scenarios might be.
- We've also invented another technique that allows for incredibly small deflection measurements to be taken over long distances. It is the most accurate method we have been able to find anywhere by far and it is incredibly cost and time efficient as well. We have used it for measuring deflections over large spans of bridges as well as monitoring for movements in walls for example.
- We have developed some specific techniques for bridges, such as an improved method for load ratings and inspections. We see now how these techniques may also be used in other applications besides bridges.
- In general, our innovation provides more data, higher quality data, and is a fraction of the cost and time as traditional methods.



Mach85 presents its innovation at the CCA Annual Conference. (7 minutes)

"The code required many detailed measurements to be made, but there was no practical way to do these measurements, so inspectors would rely on their own eyeball estimates and subjective determination of the health of the structure. We immediately saw how we could combine our 3D measurement software with other techniques like artificial intelligence to solve this problem."

Shaun Kennedy, CEO, Mach85

Combining proprietary 3D measurement software with other techniques, like artificial intelligence, allows CONtact mentee Mach85 to respond to major issues in the current methods of inspecting and analyzing the health of infrastructure.

4 Digital twins, Virtual Reality (VR) and Augmented Reality (AR)

4

Digital twins, Virtual Reality (VR) and Augmented Reality (AR)

Current state of the industry:

Construction

Total world economy

Manufacturing

Globally, labour-productivity growth in construction has averaged only one per cent a year over the past two decades, compared with a growth rate of 2.8 per cent for the total world economy and 3.6 per cent in the case of manufacturing[22].

The number of publications in the areas of AR and VR has spiked over the last two years, showing interest in the construction industry.

In the last five years, AR has undergone rapid development and implementation, compared to earlier years, with an increasing trend in articles related to the use of AR[23].

AER

Other sectors

However, in a survey and trend analysis of VR and AR adoption in the Architecture, Engineer and Construction (AER) industry, researchers found that the AEC industry is far behind other sectors in adopting AR/VR technologies[24].

22 Reinventing Construction. McKinsey Global Institute.

23 Jiaqi Xu and Fernando Moreu. A Review of Augmented Reality Applications in Civil Infrastructure During the 4th Industrial Revolution.

24 Mojtaba Noghabaei, Arsalan Heydarian, Vahid Balali and Kevin Han. Trend Analysis on Adoption of Virtual and Augmented Reality in the Architecture, Engineering, and Construction Industry.

Where are AR, VR, digital twin being used?

Some application areas of AR and VR being used by construction project managers:

Augmented Reality		Virtual Reality	
Researched application area	**%**	**Researched application area**	**%**
Construction safety management	36	Construction safety management	51
Communication and data acquisition	19	Visualization	17
Visualization	15	Communication and data acquisition	12
Construction management education	9	Construction management education	10
Scheduling and progress tracking	9	Scheduling project progress	10
Defect and quality management	6		
Facility management	6		

What are the benefits of using AR, VR, digital twin?

- Case studies have found that construction projects can reduce work time by 50 per cent and save costs by 52.36 per cent when implementing AR and VR technologies[25].
- AR systems were found to enable participants of a survey to complete their tasks 50 per cent faster than using traditional methods[26].
- In 2018, a study on the use of AR for underground utilities in Toronto found that using AR technology reduced the time required to complete a job by 50%, with a 10% productivity boost[27].
- A survey collecting interviews from 18 companies involved in 27 case studies collecting data on VR usage for three years found that[28]:
  - 81 per cent of the respondents agreed that the use of immersive VR technology during their projects improved communication, collaboration, and/or coordination among project stakeholders;
  - 93 per cent of the projects directly reported cost and time savings;
  - 85 per cent of the case studies ranked improving design review as one of the most important enablers due to its ability to streamline the occupant-related decision process and prevent design changes during construction and occupancy.

25 Moh Nur Sholeh , Shifa Fauziyah , Riqi Radian Khasani , Effect of Building Information Modeling (BIM) on reduced construction time-costs: a case study.

26 Mahmoud Albahbah, Serkan Kıvrak, Gökhan Arslan. Application areas of augmented reality and virtual reality in construction project management: A scoping review.

27 vGIS Promark Augmented Reality GIS Locate Industry Study, 2018.

28 Ozcan-Deniz. Expanding applications of virtual reality in construction industry: A multiple case study approach.

4.1

To learn more about each project, click on the title.

Examples of projects on the Construction R&D portal **Digital twins**

Imagining Canada's Digital Twin

Funding Details

Social Sciences and Humanities Research Council
- Grant type: New Frontiers in Research Fund - Exploration
- Year: 2019/20
- Total Funding: $125,000

Keywords
- AEC industry
- building information modelling
- DIGITAL TECHNOLOGIES
- Digital Twin
- smart city

Principle Investigator(s)
- Fai, Stephen
  Carleton University

Collaborator(s)
- Hebb, Tessa
  Carleton University
- Lauriault, Tracey
  Carleton University
- Ramirez, Alejandro
  Carleton University
- Santana Quintero, Mario
  Carleton University

The Role of AI, Machine Learning, and Big Data in Digital Twinning: A Systematic Literature Review, Challenges, and Opportunities

IEEE Access, Vol. 9 (2021)

Keywords
- Electrical engineering. Electronics. Nuclear engineering

Authors
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Development of a Digital Twin to Improve Safety for Impact Sensitive Composite Aircraft Structures

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2017/18 to 2019/20
- Total Funding: $66,000

Keywords
- Aerospace
- Aerospace, aeronautical and automotive engineering
- Mechanical engineering
- Transportation systems and services

Principle Investigator(s)
- Laliberte, Jeremy
  Carleton University

When implementing AR and VR technologies construction projects can reduce work time by

50 %

Examples of projects on the Construction R&D portal **Augmented reality and virtual reality**

BEAM-SCE: Building an environment for augmented reality monitoring of structures in civil engineering

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Collaborative Research and Development Grants
- Years: 2015/16 to 2017/18
- Total Funding: $166,956

Keywords
- Information and communication services
- Information systems and technology
- Information technology
- Virtual reality and related simulations

Principle Investigator(s)
- Laurendeau, Denis
  Laval University

3D Augmented Urban Space Modeling for Smart City

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Discovery Grants Program - Individual
- Years: 2014/15 to 2018/19
- Total Funding: $110,000

Keywords
- Cartography and geomatics
- Geographical information
- Information and communication services
- Information technology
- Virtual reality and related simulations

Principle Investigator(s)
- Sohn, Gunho
  York University

Enhancing building facade using mobile LiDAR

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Collaborative Research and Development Grants
- Years: 2018/19 to 2019/20
- Total Funding: $148,000

Keywords
- Civil engineering
- Construction, urban and rural planning
- Survey engineering and remote sensing
- Surveying and photogrammetry

Principle Investigator(s)
- Wang, Ruisheng
  University of Calgary

Improved geomechanical model visualization and interpretation using a combined mixed reality-virtual reality approach

Funding Details

Natural Sciences and Engineering Research Council of Canada
- Grant type: Engage Grants Program
- Year: 2017/18
- Total Funding: $25,000

Keywords
- Civil engineering
- Engineering
- Geotechnical engineering (including engineering geology)

Principle Investigator(s)
- Stead, Douglas
  Simon Fraser University

Digital twins, AR and VR — what is happening within the CCA family

3 Steps to getting started with digital twins

By: Robert Bray, Senior Director & General Manager, Autodesk Tandem

Digital twins have created a huge buzz in the construction industry. However, with limited resources, many small firms are perplexed on the best place to start deploying digital twin technology.

Let's take a look at some of the key steps to get started.

❶ Understand the high-level benefits of a digital twin

A digital twin is more than just a replica of a built asset. It's a dynamic, real-time version of a building that's closely linked to the physical asset. It takes commitment to create and maintain a digital twin, so in order to obtain buy-in from stakeholders, you need to help them understand the advantages of having one, such as:

- **Real-time and predictive performance data.** A digital twin gives you the knowledge to inform, predict, and look at future decisions based on how that asset is performing in the real world.
- **Time and cost savings.** Reduce future construction costs and schedules through the use of digital twins.
- **Streamline building maintenance.** A digital twin provides a holistic platform on which data can be continuously accessed and updated to address maintenance proactively.

❷ Start small and develop your process over time

It can be tempting to try to do as much as you can right from the get-go. It's far better to be intentional with what you build and collect. Prioritize the assets that you absolutely need to manage first and go from there.

It's also important to have a discussion with your team on what assets are required. An essential action step is getting together with the facility management team and understanding the assets they need to manage in that facility going forward, how the systems that connect those assets actually work, and what data is needed for each of these pieces.

❸ Designate a point person to maintain digital twin

The success of your digital twin doesn't just lie in its creation; you need to maintain it as well, otherwise you'll get stagnant and unusable data. Buildings and facilities change over time. Components are swapped out, renovations take place, and assets need to be updated.

Assign a point person to look after the digital twin and ensure that it evolves along with its physical counterpart. They could be part of the capital projects team or maybe even part of the facilities maintenance team.

This is a clear opportunity for contractors to become a better partner and help manage that digital data on behalf of that owner. Many times, owners don't have the detailed experience in this, and contractors do. That's one value that they can bring to the owner. It tightens up the partnership between the contractor and it facilitates better communication between the two. It's also a much longer opportunity to work together and delivers more value to the owner over time.

Start your digital twin journey today

As the Chinese proverb says, "The best time to plant a tree was 20 years ago. The second-best time is now." The same goes for any new technology deployment like digital twins. If you're interested in starting your digital twin journey, we'd love to get in touch.

I also recently shared my thoughts on the value of digital twins on Autodesk's construction podcast, Digital Builder. Listen here.

Construction Association of Prince Edward Island — bringing VR to schools to introduce students to construction careers

The Construction Association of Prince Edward Island (CAPEI) won CCA's 2021 Partner Association Award of Excellence. Promoting careers in construction has been a key focus for the association, and CAPEI has expanded its activities to include introducing students to 15 different trades courtesy of virtual reality in their classrooms.

Learn more about CAPEI — its virtual reality initiative, its drone program, and why it won CCA's 2021 Partner Association Award of Excellence (3 minutes)

Initially created in the beginning stages of the pandemic, PEI's provincial government set up case teams through Innovation P.E.I. made up of multiple students within the post-secondary educational system. Having completed a successful application to participate in the program, CAPEI met with the case team over a period of two weeks, as background research was initiated and discussions on the future of the industry were held. The case team focused on introducing the construction industry to students, and the best way to present, as well as the best age. With a connection from the team to the VR world, the idea of career capsules was born.

Initially a travelling program, visiting middle and high schools across the province, CAPEI has recently signed an agreement with the province of Prince Edward Island to put a VR unit in every high school in PEI. CAPEI's construction training centre is currently building 8x8 cubicles to house the units – creating a very bright, welcoming and visible space to experience an introduction to construction careers.

"The modules that we have are career exploration tools only. And the carpentry program, which we have just received…is amazing. You're moving around the jobsite, you're picking things up, you're cutting, you're measuring, and you're building framing and things like that – it's so real."

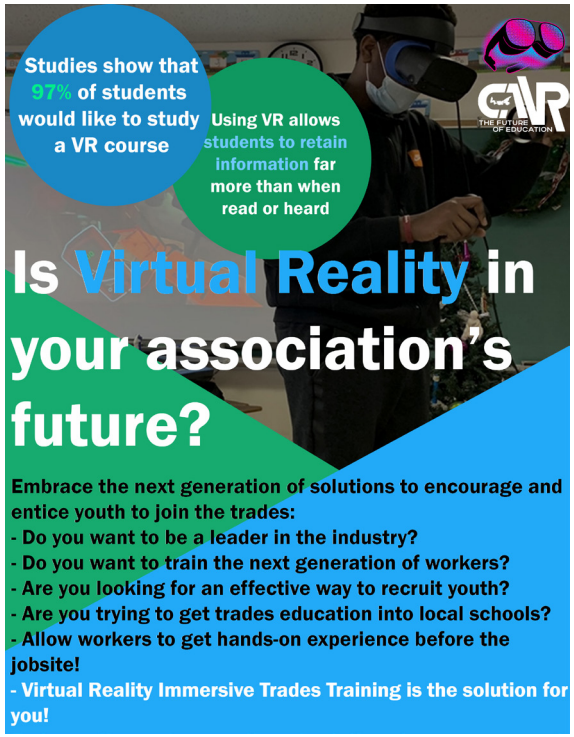
Sam Sanderson, General Manager, CAPEI

Modules

- Automotive technician
- Carpenter
- C&C operator
- Construction welding
- Heavy equipment operator
- HVAC technician
- Hydroponics operator
- Manual machinist
- Millwright Stick welding
- Mining engineer
- Mining machine operator
- Pipefitter
- Plumber
- Process engineer
- Residential construction
- Robotics technician
- Robotic welding operator
- Sheet metal worker

Coming soon:

- Aquaculture technician
- Farm labourer
- Quality assurance technician



To learn more about CAPEI's VR program, contact Sam Sanderson at sam@capei.ca.

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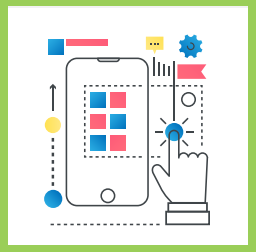
Foster innovation in your business



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A missed opportunity for Canadian construction?

When it comes to claiming tax relief for innnovative problems solving the construction sector in Canada is a notable ooutlier relative to its international peers, leaving local businesses out of pocket. **But is Canadian construction really less innovative?**

0.7 %

of the total SR&ED credit rebate in Canada is paid to construction businesses

The percentage of the total tax relief for innovative activity paid to construction businesses.

5.7 %

Over 8 times Canada.

4.9 %

7 times Canada.

2.5 %

3.5 times Canada.

1.3 %

Over 2 times Canada.

Foster innovation in your business

SR&ED credit program

When compared to other countries with similar SR&ED government guidelines, we see from our extensive research that the Canadian construction industry is not making its fair share of SR&ED claims. This can make it appear as though Canadian construction companies are not as innovative as others, yet we know that's not the case.

As seen in this graph, the construction sector in many countries with comparable incentive programs is claiming several times the amount claimed by Canadian construction businesses. Despite Canada's status as a pioneer of innovative construction methods, regularly having to overcome challenges concerning climate, logistics, ground conditions, remote working, and materials shortages, it's clear that it isn't a case of less innovation, but a case of underrepresentation.

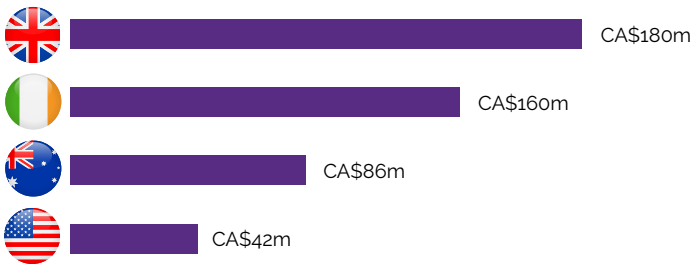
Invennt's goal is to work with the Canadian construction industry to demonstrate where their work meets the definition of innovation described tax code so they can claim under the SR&ED program. Every day we see businesses throwing away millions in unclaimed SR&ED tax credits, either because they underestimate themselves or do not fully understand the rules relating to SR&ED.

In 2022, it's time to ensure the Canadian construction industry is claiming, at a minimum, the same percentage as countries with comparable tax incentives.

CCA has partnered with Invennt to offer CCA member firms a SR&ED credit writing service to help them file claims for SR&ED tax incentives without the hassle and upfront cost of hiring additional experts, saving valuable time and resources.

To learn more, visit: SR&ED credit proposal service - Canadian Construction Association (cca-acc.com)

Additional funding available to Canadian construction businesses if the industry claimed the same percentage as countries with comparable tax incentives.

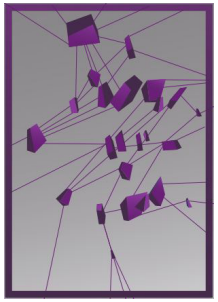


Figures based on the latest published statistics by each countries' respective revenue services.

According to the "Construction in a digital world" report, **59 %** of respondents say their organization needs to moderately or considerably adapt their digital strategy.

Digital adoption

How ready are you to keep pace with digital transformative changes in construction?



In November 2020, CCA and KPMG partnered to create a benchmarking survey to determine how far Canadian construction firms are in their digital adoption journey. The results were published in the report "Construction in a digital world".

"The industry is on the cusp of digital transformation with leading firms already adopting technology – from analytics to drones, robotics, 3D printing, and augmented reality – to yield improved productivity, safety and decision-making," says CCA President Mary Van Buren. "Our survey reveals, however, that smaller and medium-sized firms are not yet capitalizing on the benefits technology can bring. For many contractors, the low bid model simply does not allow for innovation or to invest in new technologies."

Unsure where your firm stands? The *Digital maturity assessment tool* is still available for firms to access.

The Government of Canada is offering a Canada Digital Adoption Program for small and medium enterprises.

In the 2021 Budget, the Government of Canada announced the $4 billion Canada Digital Adoption Program (CDAP) to help get businesses online, give firms' e-commerce presence a boost, or help digitalize companies' operations.

There are two (2) types of grants available –

1. Grow your business on-line and
2. Boost your business technology.

The **Boost Your Business Technology** grant covers up to 90 per cent of the eligible cost of retaining the services of a digital advisor, up to a maximum grant value of $15,000 per Canadian small/medium enterprise, to develop a digital adoption plan.

To learn more, and confirm your eligibility, click here.

6 Construction 4.0 – Perspective from KPMG in Canada

6

Construction 4.0: The transformation of the construction industry

While other industries have been reaping the benefits of the digital boom for years, the construction industry has been slow to leverage the potential of digital technologies to transform how buildings, infrastructure, industrial facilities, and other built assets are designed, constructed, operated and maintained. Given that the construction industry accounts for 6 per cent of the global GDP[1], the adoption of new technologies and ways of working could have significant economic and social impact across Canada and around the world.

Driving forces:

Projects have not delivered predictable results: Construction productivity growth has trailed other sectors by ~40 per cent since 1995[2] and there is mounting pressure on the industry to control costs and improve schedule performance. Improved project outcomes will mean more projects, better relationships, and higher profitability for all parties.

The need to collaborate and innovate: While traditional delivery models are well suited to some projects, the complex projects of today demand new approaches to contracting that drive collaborative multidisciplinary thinking and decision making in order to spur innovation solutions. These new delivery models require open and constant communication and sharing of information across project stakeholders to ensure all voices are heard and all perspectives are considered.

Aging and shifting workforce: It's well-known that the Canadian construction industry faces a workforce shortage that is projected to tighten over the next decade with over 20 per cent of workers set to retire[3]. The industry will need to adapt by leveraging technology to do more with fewer workers and rethink the kinds of skillsets and training needed to deliver a complex project (e.g., data scientists, software developers, etc.).

New possibilities offered by technology: Technological developments in recent years have changed the way we look at managing, designing, and constructing projects. From big data, analytics and machine learning to 3D printing, drone, and robotics, the industry is on the cusp of a major shift in the way projects are delivered and the levels of efficiency that can be obtained.

We call this fundamental shift in the way our industry works **"Construction 4.0"**. We believe this transformation will deliver massive improvements in the performance of the industry by driving innovative approaches to design and construction, enhancing labour productivity, reinforcing the workforce, and

1 World Economic Agenda, 2018

2 The Economist: The Construction Industry's Productivity Problem

3 Canadian Construction Association: Critical Issues – Workforce

KPMG

modernizing project delivery strategies. There is no question that it will transform the entirety of the construction value chain. The real question is who will leverage this opportunity most effectively to gain the early mover advantage and when?

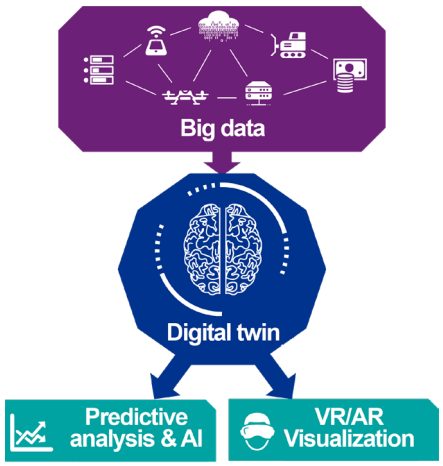
Leveraging the power of big data has historically been a missed opportunity for the construction industry. Digital twin technologies promise to be the key to unlocking hidden value in project data.

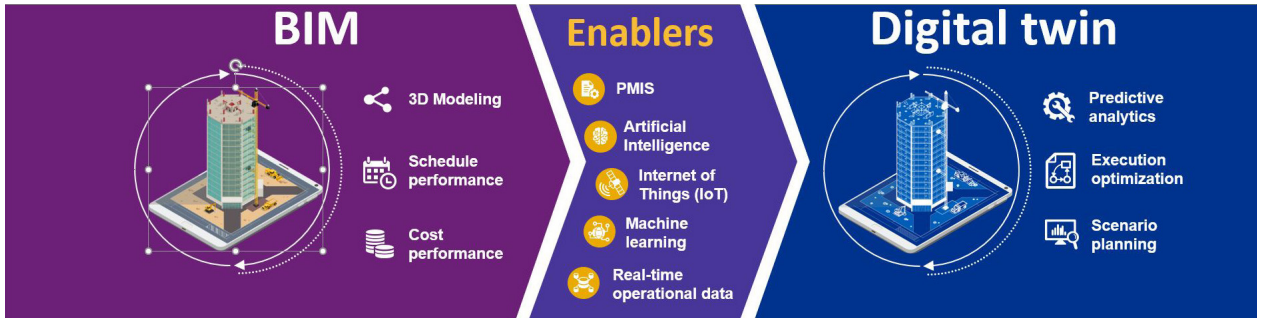
Construction 4.0: The power of data

Over the past 20 years, advancement in digital technologies have paved the way for incredible innovation and increases in productivity across nearly every sector of the economy. However, productivity in the construction industry has been stagnant and major players continue to struggle to improve quality, increase performance levels, and improve overall project outcomes.

Major projects are amazing generators of big data spanning design, contractual, cost, schedule, progress, quality, and other kinds of data, yet 96 per cent of all data captured by the construction industry never gets analyzed or leveraged[4]. With new technologies like Internet of Things ("IoT") sensors continuing to increase the volume of data collected, the question of how the construction industry manages, analyzes and uses big data will become increasingly important.

BIM has long been heralded as the technology that will help the construction industry unlock value from project data, however it has historically not been used to its full potential. Now with the advent of new enabling technologies spanning analytics, machine learning, and IoT sensors, digital twin technologies build on the functionalities of BIM to serve as the central repository for all project data and unlock new opportunities with additional technologies like predictive analytics and VR and AR visualizations.





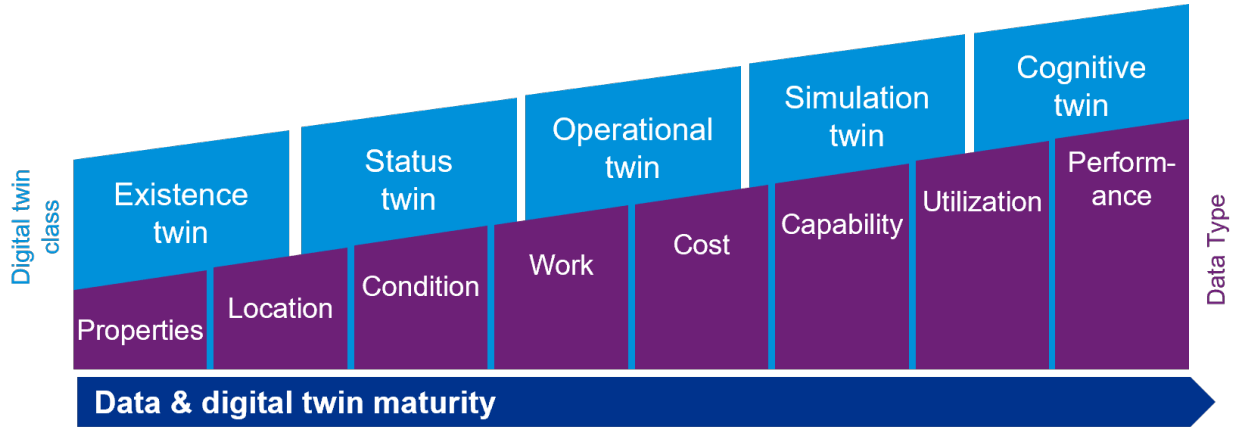
4 Big Data = Big Questions for the Engineering and Construction Industry, FMI, 2018.

Organizations do not need to develop highly advanced models to benefit from big data and digital twin technologies. Even low complexity digital twins can offer significant impact on how organizations plan, design, and execute large projects.

Digital twin levels of maturity

There is no one single definition for what a digital twin is or the capabilities it provides. There are numerous types of digital twins and levels of functionality based on the needs or the organization or project and the maturity of the data available. While development of a digital twin is a continuum, with the model evolving with the addition of new data and capabilities, KPMG has developed the below classifications to indicate the level functionality of the digital twin based on the types and level of data and capabilities that the system provides.

These classifications highlight that an organization does not need to develop a highly advanced and complex model to see value from investing in digital twin technologies. For example, existence and status twins can provide important project management insights on the physical configuration, properties, budget and cost, and as-built condition or the project and its component assets.



Existence twin: Provides core project information such as details on asset location and properties that enables a single source of truth for asset data across the project. Traditional CAD and BIM systems are examples of existence twins.

Status twin: Provides information on the status and condition of assets, often through the use of embedded IoT sensors. This can provide important insight into construction quality and progress through construction, as well as asset health over the long term, and enables prediction of future performance.

Operational twin: Enables a real-time view of the project and the operational asset. This can provide critical insights into real-time performance and risks, both through construction and operations, and enable more informed decision-making.

KPMG

Simulation twin: Enables teams to assess the impact of different design, construction, and operational decisions , allowing optimization of improvements with regard to cost, performance and risk. A simulation twin enables better and more thorough planning and can help minimize the risk of costly design and construction errors.

Cognitive twin: Leveraging AI technologies and real-time data collection, a cognitive twin takes charge of data analysis, decision making and implementation to optimize operational performance. This enables refinements to be made in real-time based on live data to adapt to current conditions.

Big data and digital twin technologies present a significant value proposition for constructors as a tool to improve operational efficiency, encourage innovation, and drive more informed decision-making.

Value proposition for the construction industry

While much of the discussion around big data and digital twins focus on the value they can provide to asset owners through the operations phase, they also present significant opportunities for contractors and design teams through the project design and construction phases. In particular, developing a digital twin early in the project lifecycle can unlock value and critical insights into the vast pools of design and construction data, allowing for more informed decision-making throughout the lifecycle of the asset.

Drive innovation: By allowing designers and constructors to collaborate and test their ideas through digital simulations, a digital twin can help expedite the design process, improve constructability and execution efficiency, and drive new and innovative solutions.

Improve cost & schedule performance: By creating clearer visualizations, automating workflows and business processes, and integrating more information, a digital twin can help to reduce costs and improve schedule performance by enabling more efficient and better-informed business decisions, and streamlining design and construction tasks.

Estimating & tendering: Leveraging big data analysis from previous projects and incorporating contract arrangements, project size, spending trends, and change orders, digital twin and predictive analytics can help estimating teams anticipate project outcomes and evaluate the attractiveness of a project.

Advanced information management technologies have been shown to provide significant value to major projects organizations. $1 invested in information management technologies could generate[4]:

Labour savings
$5-6
over time

Total operational savings
$6-7
over time

4 KPMG and Atkins, 2021, The value of Information Management in the construction and infrastructure sector"

KPMG

Actively mitigate safety risks: By monitoring the site environment, weather conditions, and other inputs, predictive analytics powered by big data can help identify risks and safety hazards to enable proactive planning and mitigations. Using enhanced simulations, a digital twin can also help improve safety by enabling workers to experience the project environment before going to site, and plan and rehearse high-risk tasks in advance.

Optimize productivity: By integrating IoT sensors, lidar scanning and other big data sources, digital twins can enable better tracking and visualization of progress and as-built conditions to allow better planning and allocation of labour and equipment allocation to maximize productivity and minimize downtime.

Increase project management efficiency: Digital twins and the ongoing modernization of the supply chain will help enable the decentralization and automation of a number of activities previously borne by the project team, spanning procurement processes and logistics to project controls and invoicing, thus creating efficiencies both in the office and at the work front.

Enable remote connection: By connecting to real-time project data and IoT sensors, a digital twin can help connect project teams from around the globe and provide real-time support to projects in remote locations when they need it most.

Support collaborative contracting: With growing interest in increasingly collaborative contracting models, digital twin and other data sharing technologies enable more open and collaborative ways of working by enabling greater sharing and integration of information across project stakeholders.

The race is on to become a technological leader in the construction industry, but there are important questions organizations must first ask themselves.

Forecasting the future: Predictive analytics

Big data, digital twin and predictive analytics have already made significant impacts across many other industries and applications, and have demonstrated their potential for the construction industry. Early adopters are already seeing the benefits of investing in these technologies and are exploring new ways to improve their operations. The race is now on for contractors, designers, and owners to see who will best leverage these technologies to drive innovation and efficiency in project design and execution, and improve overall project outcomes for all parties.

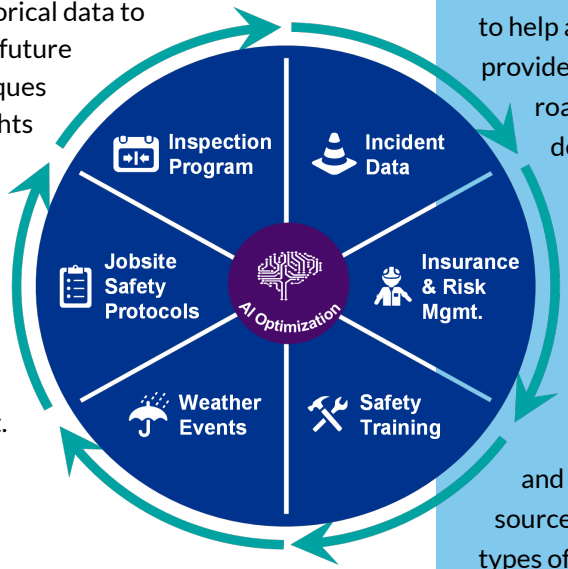
As these organizations embark on this transformation its important to consider:

- Do you have a data management strategy to consistently capture and manage project information that ensures data quality and trustworthiness?

- Do you have a solid understanding the capabilities of your current information technology suite and the additional capabilities offered by new technologies in the market?
- Do you have the right people and skillsets to take full advantage of the available technologies and drive the right insights from your data?
- Do you know what types of reporting, statistics, and KPIs are needed to inform decision making at the different levels of the organization?

Predictive analytics can leverage the vast array of information available on projects to identify risks before they occur, enabling more proactive mitigation measures.

Improved data collection and management, founded on the digital twin as the project's central data repository, opens the door to other technologies and opportunities including predictive analytics. Predictive analytics uses techniques from data mining, statistics, modeling, machine learning, and artificial intelligence to identify patterns, trends, and relationships in historical data to predict the likelihood of future outcomes. These techniques can provide critical insights to contractors and owners to help identify issues before they happen, isolate the drivers and develop mitigation strategies to reduce risk and correct the course of the project.



Case study: Analytics in action

A leading US contractor recognized the need to become a leader in data analytics in the construction industry and partnered with KPMG to help assess areas where data analytics could provide value to the organization and build a roadmap to drive strategic priorities and deliver quick-wins.

One such priority was the development of a safety analytics prediction model that would notify project teams of heightened risks for injuries. KPMG leveraged its experience in data analytics and major projects to help the contractor develop an integrated model that aggregated and analyzed data from dozens of different sources in order to assess the risk of various types of incidents in the next three days, enabling the contractor to take preventive measures and resequence work to mitigate risk and reduce the likelihood of a serious injury.

Construction 4.0: The connected project

KPMG's Global Infrastructure Advisory team focuses on the development and construction of major projects across Canada and around the world, and the forces of change on our industry. Learn more about the many new technologies poised to disrupt the construction industry and the way we deliver major projects here.

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Or attend one of our webinars:
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