Alberta Construction Association

Emerging Skill Sets Literature Review

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Introduction

Alberta Construction Association commissioned this literature review as one initiative in developing a broader workforce strategy to address improving opportunities and reducing risk for its member firms.

Innovation is rapidly changing the construction industry. As new technologies are adopted, the skill sets required by construction firms is shifting. As owners increasingly demand proficiency with new technologies as a condition of bidding, and as restrictions on foreign participation in Canadian public procurement opportunities are relaxed, Alberta's construction industry may fall behind without a coordinated effort to ensure that their workforce has the required skills to succeed.

As a first step, seventeen documents on the future of the construction industry were reviewed with the aim of identifying emerging skill sets that may be required.

A non-exhaustive survey of available training options and research was conducted to highlight how the industry in Alberta is responding to the challenge of these emerging needs.

Background

The construction industry globally has been dogged by two negative trends: historically low productivity growth and the lack of skilled labour.

Compared to other industries, productivity growth in construction has been stagnant, and in some markets negative, over the last few decades. This has been attributed to multiple factors, such as fragmentation in the industry, increasingly complex projects, and low returns on initial investments.[1]

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[1] Blanco et al., *The New Age of of Engineering and Construction Technology*, p. 1

However, uptake of new technologies that could raise productivity has also been low, and construction has not fundamentally changed in the last 50 years.[2] The construction industry spends considerably less on research and development than other industries.[3]

Lack of skilled labour is widely acknowledged as a key challenge facing the industry. In a recent World Economic Forum survey, more than three-quarters of respondents agreed that the industry is not doing enough to attract and retain talent, and none of the respondents fully agreed that the industry is investing enough in recruitment.[4]

The shortage in skilled personnel will only get worse, as the workforce ages and other new skills become necessary.[5] Investment in automation and other labour-saving technologies may be necessary not only to raise productivity, but to solve future labour shortages.[6]

Changing Skill Sets and Attracting New Talent

The type of skill sets that the construction industry will need to attract and retain will be different than those of the past. New technologies are increasingly displacing the need for low skilled workers, but utilizing these technologies requires a highly-skilled workforce with different skills.[7] Up to 50% of current positions in the industry could be automated[8], especially in repetitive, manual tasks such as bricklaying.[9]

The type of skills needed to drive innovation - such as digital literacy, data analysis, and online collaboration - are also being pursued by other sectors such as the technology industry. Construction firms will increasingly have to compete for talent with top firms such as Google or Apple[10], and will need to become a "magnet for digital natives".[11]

To successfully attract talent, the industry will have to make itself more attractive to potential recruits. A major barrier to attracting the high-skill talent needed is the poor public perception of the construction industry. Construction is seen as "dull and dirty", not innovative or forward-thinking.[12] Two-thirds of respondents in a YouGov poll said they would never consider a career

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[2] World Economic Forum, *Shaping the Future of Construction - Inspiring innovators redefine the industry*, p. 9

[3] Rajat Agarwal, Shankar Chandrasekaran, and Mukund Sridhar, *Imagining construction's digital future*, p. 2

[4] World Economic Forum, *8 ways the construction industry can rebuild itself for the 21st century*, p. 2

[5] Santiago Castagnino, Michael Buehler, and Ibrahim Odeh, p. 4

[6] Sabine Hoover, Jay Snyder and Alyssa Menard, *Automation and Robotics: Rethinking Engineering and Construction Jobs*, p. 1

[7] World Economic Forum, *Shaping the Future of Construction - A Breakthrough in Mindset and Technology*, p. 13

[8] Sabine Hoover, Jay Snyder and Alyssa Menard, p. 1

[9] Balfour Beatty, *A Digital Future for the Construction Industry*, p. 5

[10] World Economic Forum, *8 ways,* p. 2

[11] Gerbert et al., *Digital in Engineering and Construction,* p. 14

[12] World Economic Forum, *8 ways,* p. 5

in the construction industry[13]. A "prestige gap" exists, with 91% of survey respondents believing that people working outside the industry have a different perspective than those working within it.[14] Industry needs to do a better job communicating the desirable aspects of construction to potential talent sources.

Diversity is also a recruitment issue in the industry. A clear link exists between diversity and innovation, but male employees with an engineering background still predominate in the industry.[15] In an industry where women constitute just 9% of the workforce[16] there is a need to "boost positive culture around women in the industry".[17]

Emerging Skill Sets

Humans with traditional construction skill sets are unlikely to be replaced in the near future.[18] But construction firms must invest in new emerging skill sets in order to maintain competitiveness in a changing environment. To aid analysis, these skill sets have been categorized in six groups: Advanced Manufacturing Techniques, Smart Equipment, Lean Construction, Integrated Project Delivery, Building Information Modelling, and Data Management and Analysis. However, it is important to note that this classification is somewhat artificial, as various technologies are used in or supported by more than one category.

Advanced Manufacturing Techniques

New technologies such as prefabrication, 3D printing, and automation are changing the way that projects are constructed, and shifting the required skill sets. Projects in the future may require less traditional building trades, and more people skilled in programming and using semi-autonomous machinery.

Prefabrication and modularization reduces the need for manual labour[19], reduces waste and eliminates weather related delays.[20] Production in a factory setting also can create safer working environments.[21] The McKinsey Global Institute estimates that firms changing from a project-based to a manufacturing production system could experience productivity gains of five to ten times[22].

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[13] World Economic Forum, *Shaping the Future of Construction - Future Scenarios and Implications for the Industry,* p. 20

[14] BRE Academy, *Boardroom to Building Site Skills Gap Survey*, p. 1

[15] World Economic Forum, *8 ways,* p. 3

[16] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 42

[17] BRE Academy, *Boardroom to Building Site Skills Gap Survey*, p. 2

[18] Sabine Hoover, Jay Snyder and Alyssa Menard, p. 5

[19] World Economic Forum, *Inspiring innovators*, p. 34

[20] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 19

[21] Gerbert et al., p. 8

[22] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity*, p. 20

Though still in the early stages, 3D printing is expected to have a "disruptive impact", with productivity gains of up to 80% for the manufacture of certain customized components.[23] 3D printing is being used in multiple application, from creation of difficult to fabricate parts, to prefabrication of building sections, and the printing of entire structures. Skilled workers will be needed to operate and maintain the printing machinery.

Responses in Alberta

The NSERC Industrial Research Chair in the Industrialization of Building Construction at the University of Alberta is undertaking research to improve productivity for modular and off-site manufacturing.

Smart Equipment

Automation has begun to replace manual labour in certain application - including the use of autonomous bulldozers or welder robots.[24] Autonomous equipment has the potential to increase health and safety by replacing humans in dangerous work. While their use is currently limited, Balfour Beatty predicts that by 2050 most of the construction process will be automated, with humans remotely managing multiple projects by accessing visuals and data from the on-site machines.[25]

Drones are increasingly used to track people, machinery and components as they move through the construction site.[26] Drones equipped to with cameras are used to survey and inspect sites, including autonomous out-of-sight flights.[27] They have also been equipped to generate 3D footage, which is compared to models in real time to track progress and identify deficiencies.[28] They are also used in retrofit and maintenance projects, using aerial mapping and laser scanning to create 3D models of buildings.[29]

New equipment will also change how traditional tradespeople work on construction sites. Wearable exoskeletons are already in use to increase productivity and safety for tasks that require heavy lifting and repetition.[30] Bricklayers have been trained to manage a bricklaying robot, which can lay 3,000 bricks during a work day using a conveyer belt and robotic arm.[31] Other technologies such as augmented reality tools can enable lower-skilled workers to perform complex, higher skill work.[32]

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[23] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 22
[24] World Economic Forum, *Inspiring innovators*, p. 62
[25] Balfour Beatty, p. 16
[26] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 24
[27] Gerbert et al., p. 5
[28] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 32
[29] Gerbert et al., p. 6
[30] Balfour Beatty, p. 17
[31] Sabine Hoover, Jay Snyder and Alyssa Menard, p. 3
[32] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 36

Utilizing these new technologies effectively require people with skill sets that may not have even existed a decade ago. As an example, "thousands of drone pilots and drone data analysts" are needed in the industry, which was not previously foreseen.[33] It is difficult to predict what skills may be necessary in the future, but fostering a culture of continuous learning and development is essential in a "radically changing industry environment that requires different skills".[34]

Responses in Alberta

Drone pilot training is available at some post-secondary institutions in the province such as SAIT and Bow Valley College.

Construction management and building scanning and modeling is one of the focuses of the Centre for Innovation and Research in Unmanned Systems at SAIT.

Lean Construction

Though widespread in other sectors such as the automotive industry, lean methods is still not widely prevalent in the construction industry, despite the relatively low investment needed.[35] Lean principles seek to reduce complexity and uncertainty, which increase productivity and profitability by eliminating waste and non-value adding activities.[36]

Construction's project base nature presents unique difficulties to applying lean methods, but the payoff is significant; widespread use could reduce completion times by 30% and cut costs by 15%.[37]

Firms need to invest in training and acquiring talent that can implement lean principles on their projects. Successfully implementing lean principles requires collaboration throughout the value chain; firms need to provide training and motivation not only to their new and existing workforce, but to everyone on site, including the personnel of their subcontractors.[38] Contractors that fail to implement lean methods "risk falling behind in their increasingly competitive markets".[39]

Responses in Alberta

The Lean Construction Institute of Canada is active in Alberta, with communities of practice established in Edmonton and Calgary.

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[33] Balfour Beatty, p. 14

[34] World Economic Forum, *8 ways,* p. 4

[35] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 30

[36] Greiser et al., *The Lean Advantage for Large Construction Projects,* p. 5

[37] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 10

[38] Greiser et al., p. 11

[39] Greiser et al., p. 14

Training is offered by several Local Construction Associations, including Edmonton, Calgary, Red Deer, and Lloydminster, and third-party training providers.

Integrated Project Delivery

The structure of traditional construction contracts is one of the highest barriers to greater productivity in the industry.[40] Traditional arrangements can hamper communication and collaboration, fail to incorporate project uncertainties and ineffectively share risk among stakeholders.[41] Alternative delivery methods have become increasingly popular to mitigate these disadvantages.

Integrated Project Delivery (IPD) is a delivery system characterized by a multiparty agreement and very early involvement of key participants in the construction project.[42] IPD projects may also include mechanisms for sharing risk and reward, equality of stakeholders, limiting liability, and transparent finances[43]. Such arrangements are intended to increase collaboration between owners, designers, and contractors.

IPD has been shown to have a superior performance in metrics related to quality, communication, and change performance[44] and overwhelmingly positive responses in a survey of stakeholders that had engaged in IPD projects.[45] IPD can also facilitate the use of other emerging skills such as Lean Construction, being seen by some owners as "the logical delivery method to extend their Lean thinking to a building project".[46]

However, IPD is still used by a minority of projects. While there are concerns around risk, legal instruments, and insurance, there is also a need for "new competencies and skills relating to collaboration and information management to support IPD".[47]

Responses in Alberta

The Integrated Project Delivery Alliance (IPDA) is a national organization that was founded in Alberta. The IPDA offers training and awareness events, and funds research.

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[40] McKinsey Global Institute, p. 48

[41] McKinsey Global Institute, p. 73

[42] Mounir El Asmar, Awad Hanna, and Wei-Yin Loh, "Quantifying Performance for the Integrated Project Delivery System as Compared to Established Delivery Systems", p. 2

[43] University of Minnesota, *MOTIVATION AND MEANS: How and Why IPD and Lean Lead to Success,* p. 1

[44] Mounir El Asmar, Awad Hanna, and Wei-Yin Loh, p. 13

[45] Renee Cheng, Markku Allison, and Carrie Sturts Dossick, *IPD: Performance, Expectations, and Future Use,* p. 4

[46] University of Minnesota, p. 20

[47] David Kent and Burcin Becerik-Gerber, "Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery", p. 816

Training sessions are available from some Local Construction Associations, such as Edmonton, Calgary, Red Deer (in collaboration with Red Deer College) and Lloydminster.

Building Information Management

Building Information Management (BIM) is the 3D model based successor to Computer Aided Design (CAD), and forms the software control layer for many other supporting technologies (BCG 4). BIM provides a collaborative shared model extending through a building's life cycle.

BIM is a growing market, worth $2.5 billion and growing at more than 15% per year.[48] The benefits of investing in BIM are clear - 75% of adopters reported positive return on investment.[49] BIM also provides ancillary opportunities, through new ways of information sharing between stakeholders[50] and providing the foundation for lean construction.[51]

However, as a collaborative tool, the full benefits of BIM are realized when all participants in the value chain are actively contributing. First movers may see little initial benefits.[52] Both owners and contractors need to dedicate resources for BIM implementation and invest in capability building.[53]

<u>Responses in Alberta</u>

The Alberta Centre of Excellence for Building Information Modeling (aceBIM) brings together industry, government, and academia on its board of directors.

Communities of practice exist in Edmonton and Calgary, and training is available from a wide selection of post-secondary institutions and Local Construction Associations.

Data Management and Analysis

One of the largest emerging opportunities is the collection, analysis, and use of data. Of the vast amounts of data generated by construction sites, currently the "majority of which is not even captured, let alone measured and processed".[54]

However, this is changing rapidly. Embedded sensors linking objects to the internet are available at an increasingly affordable cost.[55] These sensors can provide constant streams of

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[48] Gerbert et al., p. 15
[49] Agarwal, Rajat, Shankar Chandrasekaran, and Mukund Sridhar, p. 6
[50] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 10
[51] Gerbert et al., p. 16
[52] World Economic Forum, *Breakthrough in Mindset and Technology*, p. 25
[53] Agarwal, Rajat, Shankar Chandrasekaran, and Mukund Sridhar, p. 7
[54] Agarwal, Rajat, Shankar Chandrasekaran, and Mukund Sridhar, p. 9
[55] Gerbert et al., p. 5

data during both construction and during operation of the project. The number of embedded sensors is projected to grow from 3.5 billion now to 1 trillion by 2022.[56]

The data collected from the growing number of sensors will be used to preemptively identify issues. They have the potential to reduce unexpected failure by 50%, improve building-management productivity by 20-30% thanks to less need for inspections, and improve the building's energy performance by 10% over its lifetime.[57]

Managing and making sense of all of this data will introduce new skill requirements not traditionally required by the construction industry. It will require new software, algorithms, and databases, along with the skilled IT personnel, data scientists, and analysts to implement them and analyze the results.[58]

Control over this amount of data will also introduce new challenges around privacy and cyber security. Constructions firms will need to to protect end user privacy by ensuring high levels of data encryption and anonymisation.[59] Building sensors that control access and vital systems are vulnerable to "increasingly frequent and sophisticated attacks".[60] This will require firms to increasingly compete with other industries for cybersecurity and data privacy experts.

Responses in Alberta

NAIT's Centre for Sensors and System Integration partners with industry to develop and commercialize sensor-based applications.

Training on data management and analysis is available from some Local Construction Associations.

Conclusion

As the emerging skill sets explored above become more mainstream, construction in Alberta will transform. Adopting new innovations have the potential to solve construction's productivity problem, but successfully implementing new technologies and ways of doing business bring their own challenges around attracting and developing talent.

Local Construction Associations are providing education opportunities to members, coordinating communities of practice, and creating partnerships between firms and third-party training providers. Alberta post-secondary institutions are advancing research in these emerging areas and partnering with industry to test new technologies and methods.

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[56] Balfour Beatty, p. 20
[57] World Economic Forum, _Breakthrough in Mindset and Technology_, p. 23
[58] Balfour Beatty, p. 20
[59] Balfour Beatty, p. 20
[60] Balfour Beatty, p. 21

Some of these responses were highlighted in the relevant sections above, but this does not represent an exhaustive list of all of the work being done in these areas. Due to the rapid pace of change, any complete inventory would become outdated almost immediately. However, an opportunity exists to coordinate a province-wide survey of members to quantify the industry's level of engagement and challenges experienced in implementing these emerging skill sets.

Recommendation - Survey industry members on their level of engagement with new technologies and barriers to talent acquisition.

Bibliography

Agarwal, Rajat, Shankar Chandrasekaran, and Mukund Sridhar,*Imagining construction's digital future*, McKinsey and Company, 2016

Balfour Beatty, *A Digital Future for the Construction Industry,* 2017

Blanco, Jose Luis, Andrew Mullin, and Kaustubh Pandya, and Mukund Sridhar, *The New Age of of Engineering and Construction Technology*, McKinsey and Company, 2017

BRE Academy, *Boardroom to Building Site Skills Gap Survey*

Castagnino, Santiago, Michael Buehler, and Ibrahim Odeh, *8 ways the construction industry can rebuild itself for the 21st century*, World Economic Forum, 2017

Cheng, Renee, Markku Allison, and Carrie Sturts Dossick, *IPD: Performance, Expectations, and Future Use,* University of Minnesota, 2017

El Asmar, Mounir, Awad Hanna, and Wei-Yin Loh, "Quantifying Performance for the Integrated Project Delivery System as Compared to Established Delivery Systems", *Journal of Construction Engineering and Management* 139, no. 11 (2013): 1-14

Gerbert, Philipp, Santiago Castagnino, Christoph Rothballer, Andreas Renz, and Rainer Filitz, *Digital in Engineering and Construction*, The Boston Consulting Group, 2016

Greiser, Christian, Roland Haslehner, Santiago Castagnino, Armin Lohr, Pascal Engel, and Ailke Heidemann, *The Lean Advantage for Large Construction Projects*, The Boston Consulting Group, 2015

Hoover, Sabine, Jay Snyder and Alyssa Menard, *Automation and Robotics: Rethinking Engineering and Construction Jobs,* FMI Builtworlds

Kent, David and Burcin Becerik-Gerber, "Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery", *Journal of Construction Engineering and Management* 136, no. 8 (2010): 815-825

McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity*, February 2017

University of Minnesota, *MOTIVATION AND MEANS: How and Why IPD and Lean Lead to Success*, Research report, November 2016

World Economic Forum, *Shaping the Future of Construction - A Breakthrough in Mindset and Technology*, 2016

World Economic Forum, *Shaping the Future of Construction - Future Scenarios and Implications for the Industry*, 2018

World Economic Forum, *Shaping the Future of Construction - Insights to redesign the industry*, 2017

World Economic Forum, *Shaping the Future of Construction - Inspiring innovators redefine the industry*, 2017