# IRC KeyNotes

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## INDUSTRY PARTNERS

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Construction Owners Association of Alberta (COAA)

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Suncor Energy Inc.

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# Partnership in Productivity: A COAA-IRC Retrospective

SARAH MILLER



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Over 20 years ago, then-assistant professor Dr. Aminah Robinson Fayek attended a committee meeting with the Construction Owners Association of Alberta (COAA) shortly after arriving at the University of Alberta. At this meeting, Dr. Robinson Fayek was introduced to the first of many industry concerns that she would work on in the coming years: How can the industrial construction sector make more effective use of apprentices? In the commercial construction sector, projects tend to actively employ apprentices as often as journeymen. This has historically not been the case on industrial construction projects, with safety and productivity being cited as two major concerns.

Dr. Robinson Fayek worked with the COAA to define a study to see what the impact of apprentice use was on safety and productivity in the industrial construction sector. The study was implemented on the Athabasca Construction Joint Venture, a major Shell project in Fort Saskatchewan, and it led to recommendations on how to increase the ratio of apprentices to journeymen on industrial construction sites without negatively impacting safety or productivity. With the proper safety training, the study found, apprentices are just as productive as journeymen on some tasks. Construction companies can therefore be confident hiring more apprentices for industrial jobs, thereby reducing costs and providing apprentices with much-needed training on industrial sites.

Another important finding of the study was that the on-the-job portion of apprenticeships was often not structured to provide apprentices with a variety of experiences; rather, the focus was simply on making sure they got their hours. Based on this study, the COAA committee came up with recommendations

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for a managed rotation of apprentices through various tasks on the job site, increasing the breadth of experience for apprentices.

This original collaboration between the COAA and Dr. Robinson Fayek set a precedent for industry-relevant innovative research that continues to be upheld. Larry Staples, an advisor to the COAA who has been working with Dr. Robinson Fayek for many years, notes the unique way that Dr. Robinson Fayek and the IRC team are able to harness theoretical research for the development of practical solutions that can be directly implemented by construction companies—a move that is not always present in academic research. By working with the COAA, Dr. Robinson Fayek has been able to perform studies that are tailor-made to alleviate pressing industry concerns, including, for example, studies on measuring and accounting for rework, addressing workforce absenteeism, improving construction productivity and crew motivation, and measuring the impact of advanced work packaging on project performance.

The COAA works with numerous stakeholders in the construction industry to identify key issues, and through the IRC's partnership with the COAA, Dr. Robinson Fayek and the IRC team are able to work on those issues and have a significant, direct impact on the industry. This impact was recognized earlier this year when the COAA presented Dr. Robinson Fayek with the Don Currie Award, which is given to "individuals whose dedicated service has contributed to the success of the COA"—she is the first academic to be honoured with this award. It is rare in the academic world for a researcher to be acknowledged in such a way by industry, and for Dr. Robinson Fayek, "to get industry recognition from an influential group like [the COAA] was very special."

In 2014, the COAA launched "Twice as Safe, Twice as Productive by 2020," a vision that mirrors the focus of Dr. Robinson Fayek's first collaboration with the COAA. According to the COAA, "Productivity can't come at the expense of safety—they have to work in tandem. That's why thinking about productivity at all stages of a project, from planning, through contracting, procurement, and site work, can ensure a project's value chain is working effectively, while keeping people safe." While Dr. Robinson Fayek's studies on measuring and tracking rework have attracted the most industry queries, productivity is a topic that has inspired several cooperative studies, from early benchmarking studies that are being expanded by the Construction Industry Institute (CII) to more recent studies on capital productivity and capital effectiveness.

In February 2018, Dr. Robinson Fayek and then MEng student Selam Ayele, who has since graduated, presented a report to the COAA on developing a "Framework for Total Productivity Measurement of Industrial Construction Projects." Construction productivity can be measured at three levels: activity, project, and industry. However, most methods of measuring productivity do not take all project activities and resources into account. This study therefore developed a framework that considers the impact of all activities and resources on productivity and proposed a metric for measuring the total productivity of construction projects. Once productivity can effectively be measured, data collected through this process can be analyzed and used to determine ways of improving productivity.

To complete this study, a focus group made up of industry experts was convened to evaluate the proposed productivity metric and verify the framework. This is yet another advantage of collaborating with the COAA: connections are made to companies working in the Albertan construction industry who can provide real-world feedback on theoretical approaches to solving industry problems. In addition, students of the IRC not only gain academic skills, but also have the chance to experience industry work through on-site data collection and discussion with experts. Several students have been hired after graduation by COAA member organizations who have seen firsthand the valuable skills and unique perspective that IRC graduates bring to the industry. Most recently, MSc graduate Yonas Halala was hired by Suncor in part based on his work studying advanced work packaging.

The COAA is a leader in the Albertan construction industry that brings people together to work on issues that affect the entire industry, and Dr. Robinson Fayek and the IRC team are appreciative of the opportunities this collaboration provides. The industrial construction sector is very large, but the COAA manages to represent the industry through a tightknit group of people who are dedicated to improving performance and promoting excellence in industrial construction and maintenance in Alberta. The IRC team is proud to contribute to the accomplishment of these goals and looks forward to many more years of productive collaboration. ∎



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"To get industry recognition from an influential group like the COAA is very special."

— Dr. Aminah Robinson Fayek

## Complementary research programs lead to greater innovation

Since 2007, the IRC in Strategic Construction Modeling and Delivery has been collaborating with industry to develop novel approaches for solving construction-related problems and developing decision support systems based on fuzzy logic, other artificial intelligence techniques, and simulation methods. I am pleased to announce that the IRC will support and be supported by three other research programs that I am heading: a Tier 1 Canada Research Chair, an NSERC Discovery Grant, and a Future Energy Systems project. These four programs form the major components of a research plan that will make substantial contributions to the advancement of the construction industry. By undertaking four complementary programs in conjunction, more significant opportunities for innovation will be created than any one program alone could provide.

In October 2017, I began my tenure as Tier 1 Canada Research Chair (CRC) in Fuzzy Hybrid Support Systems for Construction. Tier 1 CRC appointments are reserved for "outstanding researchers
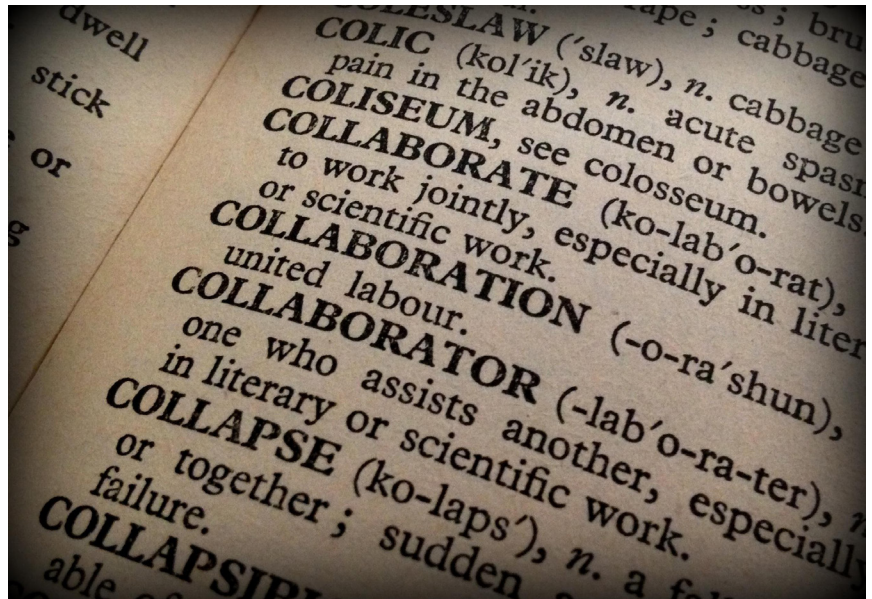


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acknowledged by their peers as world leaders in their fields," and I am privileged to be part of such an impressive group of researchers. My CRC program will expand upon our significant work on artificial intelligence, and the resulting techniques will then be implemented in a framework of integrated software tools that will support the planning, execution, and control of projects in a range of construction sectors, including building, industrial, and civil infrastructure. Throughout the past 12 years of IRC research, I and my team have created many tools and processes for facilitating project development and execution. Through the CRC, we aim to connect these previously developed tools with new techniques and technologies so that they can all "talk" to each other and exchange data over different hierarchical layers. The integrated framework will provide many innovative ways to increase the performance of organizations in the construction sector. For example, it will be used to evaluate the effectiveness of different strategies for managing construction projects, help improve construction productivity, better manage risks and uncertainties, and capitalize on the power of artificial intelligence techniques to manage and process the significant data and expert knowledge that is produced on projects. By increasing performance in the construction sector, the framework will also lead to increased competitiveness and a higher return on investment, which will in turn lead to increased investment and the creation of jobs in the Albertan and Canadian construction industries.

The NSERC Discovery Grant, while more narrowly focused in scope, provides for research into an important aspect of construction performance: organizational competencies, which are include the resources, knowledge, skills, technologies, and practices that enable organizations to gain competitive advantages and achieve better performance. The ability to model competencies and their effects on performance is essential for forecasting performance, identifying those competencies that require improvement, and developing performance enhancement strategies. The goal of the research conducted through the Discovery Grant is to develop a first-of-its-kind multilevel modeling framework that can be used by researchers and practitioners to more easily improve their performance and bring about effective changes in practices, leadership, and culture.

In 2016, the Government of Canada launched the Future Energy Systems project through the Canada First Research Excellence fund. The $75-million undertaking involves 75 projects run by 125 researchers in eight faculties over seven years, and it focuses on helping Canada transition to a low net-carbon energy economy. I am the principal investigator researching decision support systems for the improved construction and maintenance of non-electrical infrastructure for energy. This project entails developing innovative modeling and decision-making approaches that can be used to address the unique characteristics of and uncertainties inherent in the construction of future energy infrastructure. Previous research on dealing with risk and uncertainty in construction will inform the development of new tools and models that can be used on construction projects that have yet to be initiated, and the results obtained through this research will in turn increase knowledge that can be leveraged in research being done in the IRC, the CRC, and the Discovery Grant.

While the CRC, the Discovery Grant, and Future Energy Systems are separate research pursuits from those conducted in the IRC, the four programs work in conjunction towards the overall goal of improving performance and productivity in the construction sector by advancing research into artificial intelligence and simulation techniques, thereby bringing organizations to the forefront of innovation and providing them with cutting-edge tools and techniques. As our partners in the IRC, we hope that you will be the first to benefit from the research-based solutions that we are developing.

In May 2018, I received a significant honour: at the COAA Best Practices Conference, I was presented with the Don Currie Award of Recognition, which is given each year to an individual

## Message from the Chair

Foundry / PIXABAY

whose long-standing and dedicated service has contributed to the success of the COAA. Don Currie was Managing Director of the COAA when I first started working with the organization, and he welcomed me into an enduring partnership. I am grateful to have had the privilege of learning from tradespeople, COAA committee members, and senior leaders in industry. This partnership continues to have a substantial impact on the research of the IRC, and together all the members of the IRC team are contributing to the development of construction industry best practices and new tools and methods for improving the competitiveness of the construction industry in Alberta, Canada, and the world. I look forward to many more years of collaboration.

Over the past year, the IRC has seen several changes as students have graduated and completed a number of projects, specifically our studies on combining experts' opinions for construction risk analysis and contingency, advanced work packing and workface planning, and capital project productivity and effectiveness. More information on our graduating students is provided in the People section of the newsletter, on pages 5 and 6. Some of our other projects will be moving on to next stages, including our studies on construction productivity analysis and modeling, modeling construction crew motivation and performance, and construction organizational competencies and performance. We are actively recruiting projects for these studies. In addition, we are developing several software tools, including the Organizational Competencies and Project Performance Tool© (OCPPT©) and Productivity Tracker©. The OCPPT© evaluates project competencies and key performance indicators in order to determine the most significant competencies affecting project performance; Productivity Tracker© analyzes productivity data and determines the most significant factors affecting productivity in different

project contexts. We are in the process of turning the Advanced Work Packaging Assessment Tool© into an Excel application to increase its ease of use, and we are also developing Fuzzy Risk Analyzer©, a program for analyzing risk and contingency that will be presented at a workshop in early 2019, where we hope to see many partner attendees. Finally, I am proud to announce that Emerald Publishing has published *Fuzzy Hybrid Computing in Construction Engineering and Management: Theory and Applications*, an introduction to fuzzy logic and a survey of emerging research trends in the area of fuzzy hybrid computing techniques in the field of construction engineering and management, for which I served as editor. Several members of the IRC team wrote insightful chapters on both the theory and application of fuzzy logic within the construction industry, and our contributions fit seamlessly with chapters provided by scholars and practitioners from eleven countries. We hope that this book will inspire more research into uses of artificial intelligence—particularly fuzzy logic—in the construction industry.

I am pleased with the productivity and direction of the IRC, and I am looking forward to seeing the cumulative results of the research that we will continue to pursue through all of our programs. Our IRC partners are, as always, an integral part of the team, and I am glad that we are able to maintain a high level of communication. As we move forward with our research, it is important that we work with our partners to improve the robustness of our findings and the applicability of our developed tools. I would like to thank NSERC and our IRC partners for their dedication to and participation in our research pursuits. The work that we are doing not only helps our partners, but also contributes to innovation in construction and the increased competitiveness of the industry in Alberta and across Canada. ■

# The IRC team



The IRC welcomes new team members (from left to right):
Kassa Demissie
Sahand Somi
Hamed Fateminia
Yisshak Gebreteke

Mohammad RAOUFI

The IRC is proud to have seen the graduations of several students over the past year. MSc student Natalie Monzer completed her thesis on combining experts' opinions for construction risk analysis and contingency. The goal of this project was to develop a framework for combining experts' assessments of project risks and opportunities in order to determine contingency, thereby improving the construction risk analysis process. Natalie is currently exploring opportunities to put her experience to use in the United States. MEng student Selam Ayele developed a productivity measurement metric that can assess capital effectiveness and the total productivity of a construction project, making it possible for practitioners to target for improvement those input resources that are used least efficiently, thereby increasing overall productivity. MSc student Yonas Halala studied the costs and benefits of advanced work packaging (AWP) and workface planning, developing a framework for assessing these processes and evaluating the relationship between AWP maturity and AWP performance. The IRC congratulates Yonas on being hired by Suncor after his graduation, and we are happy that he will continue to contribute to innovation in the construction industry in Alberta.

Two of our PhD candidates also graduated this year. Dr. Nima Gerami Seresht successfully defended his thesis, *Fuzzy System Dynamics Modeling of Construction Productivity*, in which he presented the results of his research into the productivity of equipment-intensive construction activities, which are those activities for which productivity is driven by equipment, rather than labour. The IRC is pleased to welcome Dr. Gerami Seresht to his new role as postdoctoral fellow focused on investigating how to address risk and uncertainty on future projects for non-electrical infrastructure, such as wind farms. Dr. Robinson Fayek is the principal investigator for this project, which is part of the Future Energy Systems program. Dr. Mohammad Raoufi's thesis, *Fuzzy Agent-Based Modeling of Construction Crew Motivation and Performance*, explores the effects of construction crew motivation on performance. Dr. Raoufi's research led to the development of advanced models that help managers and decision makers find ways to improve construction crew motivation and

performance. These models take into account not only the interactions of crews working on the project, but also the subjective uncertainties in model variables such as crew motivation. The IRC is also pleased to welcome Dr. Raoufi as a postdoctoral fellow for the IRC program, where he provides support to graduate students and conducts research for the benefit of our IRC partners and the construction industry as a whole. The IRC congratulates Dr. Rodolfo Lourenzutti, former IRC postdoctoral fellow, on his recent appointment as postdoctoral teaching and learning fellow in the Master of Data Science program at the University of British Columbia. He was a valuable member of the IRC team, and his contributions to the program are greatly appreciated.

While many of Dr. Robinson Fayek's students have graduated, several new students have also joined her cohort. Coming from Ethiopia and with a background in civil and structural engineering, PhD student Nebiyu Kedir is working with Dr. Robinson Fayek and Dr. Gerami Seresht within both the IRC and the Future Energy Systems program. Nebiyu is excited to be working with Dr. Robinson Fayek for several reasons, including her commitment to practical as well as theoretical research and her experience in artificial intelligence for construction engineering and management. Also joining the IRC team from Ethiopia are Kassa Demissie and Yisshak Gebreteke, both PhD students. In addition, the IRC welcomes Hamed Fateminia, PhD student, and Sahand Somi, MSc student, both coming from Iran. We are looking forward to seeing where their research and innovations will lead. Finally, the IRC would like to thank undergraduate co-op student Sydney Tarrabain for her valuable work over the summer, made possible through the NSERC Undergraduate Student Research Award program and the IRC. Sydney extended Yonas's work, helping to create an AWP assessment tool and user manual. Sydney was instrumental in the launch of the IRC's Twitter account and maintained a consistent online presence for the program over the summer, which will be continued by the IRC's technical writer, Sarah Miller. Sydney will continue to work with the IRC over the coming months as she works towards her engineering degree. ∎

# Behind the Scenes: Andrew Johnston

The researchers of the IRC program work closely with industry partners to develop innovative solutions to real-world problems that practitioners face every day in the area of construction engineering and management, especially in terms of decision-making. To make the implementation of these solutions easier, the IRC research team often creates software tools that can process large amounts of information and data in order to streamline the decision-making process. Some of these tools incorporate the artificial intelligence methods developed by the IRC. A dedicated computer programmer is therefore a vital member of the IRC team, and Andrew Johnston has proficiently filled this role since spring 2017.

Originally hailing from Yellowknife, Andrew completed a degree in computer science at the University of Lethbridge in 2013. While completing his degree, Andrew spent summers back home working for the Government of Northwest Territories (GNWT), where he gained experience in both web development and systems analysis. After graduating, he was hired by the GNWT to continue working as a systems analyst, where he executed a variety of projects involving planning and developing different computer programs. Andrew performed system support for both front- and back-end platforms and migrated federal applications to the GNWT for the Department of Lands; for the Department of Transportation, he developed a management system, wrote scripts to extract information from databases, and participated in long-term planning for the department's driver and vehicle registration management system.

We are lucky that Andrew eventually needed a change of pace from government work and decided to move to Edmonton, where he and his wife already had social connections, to pursue employment in other settings. Working in academia was of particular interest to Andrew, who is considering returning to school to undertake a graduate degree, and the IRC is a perfect mix of academic and industry experience that will be useful for whichever path Andrew chooses to take.

In his time with the IRC, Andrew has worked with IRC researchers on projects that directly benefit industry partners, such as Fuzzy Contingency Determinator©. Currently, Andrew is working with Dr. Robinson Fayek and her research team to create Fuzzy Risk Analyzer©, which will help construction practitioners use both data and expert knowledge in order to determine an appropriate contingency value for construction projects. This tool will be presented to industry partners at a workshop in the new year.

Although Andrew often works behind the scenes, the projects that he helps complete are a vital part of the IRC program as they turn research findings into real-world applications that have a direct impact on our industry partners. We look forward to Andrew's continuing collaboration with the IRC team and are excited to share the practical and innovative software solutions that he implements based on research performed by students, postdoctoral fellows, and Dr. Robinson Fayek. ∎



IRC programmer Andrew Johnston

Sarah MILLER

## Andrew Johnston provided programming support for

### Fuzzy Contingency Determinator©

## and the upcoming

### Fuzzy Risk Analyzer©

## Construction Owners Association of Alberta (COAA) 2018 Best Practices Conference

The Construction Owners Association of Alberta (COAA) was once again responsible for two days of valuable learning, discussion, and networking opportunities at the 26th Annual Best Practices Conference, which was held at the Shaw Conference Centre in Edmonton on May 8–9, 2018. The conference attracted more than 400 attendees, including government officials, the COAA board of directors, industry partners, and students in Dr. Robinson Fayek's IRC program. The IRC team is grateful for the opportunity to attend this conference every year and share its research through a poster session and contest, whose winner is voted upon by conference attendees. Congratulations go to former IRC PhD student, now postdoctoral fellow, Dr. Mohammad Raoufi and his poster on "Assessing the Effect of Motivation on Construction Crew Performance." Summaries of all student posters can be found on the IRC website at uab.ca/stratcon.

## 2018 ASCE Construction Research Congress

Dr. Robinson Fayek and PhD candidate Getaneh Tiruneh travelled to New Orleans, Louisiana, to attend the ASCE Construction Research Congress from April 2–4, 2018. Under the theme of construction project management, Getaneh presented his research on "A Framework for Modeling Construction Organizational Competencies and Performance." Reference provided below.

Tiruneh, G. G., and Fayek, A. Robinson. (2018). A framework for modeling construction organizational competencies and performance. *Proceedings, American Society of Civil Engineers (ASCE) Construction Research Congress 2018: Construction Project Management*, New Orleans, LA, April 2–4: 712–722.

## Focus Group on Organizational Competencies

PhD candidate Getaneh Tiruneh and Dr. Robinson Fayek hosted a focus group on identifying construction organizational competencies impacting performance. After listening to a summary of Getaneh's research into organizational competencies, 13 participants from eight Albertan construction organizations reviewed a list of competencies and performance measures and evaluated the items on the list based on their importance to the categories to which they were assigned. The analyzed results of the focus group have been submitted to a peer-reviewed journal and will be used in continuing research into how construction companies can assess competencies and improve performance.

## Web-based survey on construction productivity

The IRC team is conducting a five-minute, seven-question survey on defining construction productivity at the activity level, part of ongoing research efforts to improve productivity using AI and simulation techniques. The results of the survey will be included in a journal paper that will be submitted for peer review in the new year and shared with industry.

The IRC team would appreciate your participation in this survey, which is linked below. The survey will be open until January 4, 2019.

https://www.surveymonkey.com/r/L65CKZ6

# Book Launch

## Fuzzy Hybrid Computing in Construction Engineering and Management: Theory and Applications

9781787438699 I October 2018 I 536 pages
Save 30% at emeraldpublishing.com/bookstore with promo code EMERALD30
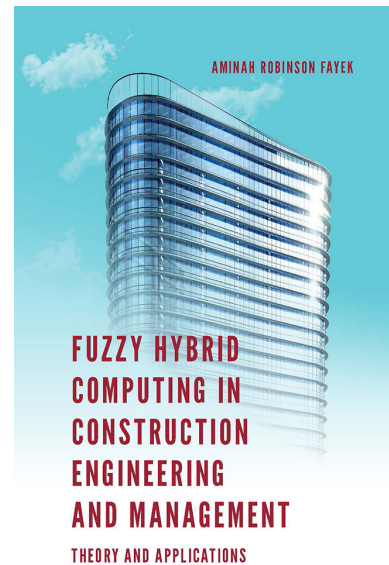


This book provides an introduction to fuzzy logic and surveys emerging research trends and the application of state-of-the-art fuzzy hybrid computing techniques in the field of construction engineering and management. Authors cover the theory and implementation of fuzzy hybrid computing methodologies for arithmetic, optimization, machine learning, multi-criteria decision-making, simulation, cognitive maps and data modelling. The practical application of these techniques to solve real-world problems across a wide range of construction engineering and management issues is also demonstrated and discussed.

The completion of effectively planned, executed and controlled construction projects is dependent on numerous interacting factors and human activities, both of which introduce vagueness and subjective uncertainty into already complex processes. While expert knowledge is an essential component of effective decision-making, analysis and consideration of expert knowledge expressed in linguistic terms remains a challenging aspect of construction engineering and management.

Fuzzy logic, which has applications in many disciplines, has the potential to address certain challenges inherent in construction engineering and management, in part because of its strengths in modelling human reasoning, dealing with subjective uncertainty and computing with linguistic terms. However, fuzzy logic alone has a number of limitations that can only be overcome by its integration with other, complementary methodologies, together leading to advanced and powerful fuzzy hybrid computing techniques.

This book is of particular interest to students, researchers and practitioners who want to learn about the latest developments in fuzzy hybrid computing in construction engineering and management.

## People's Choice Best Poster Award at the COAA Best Practices Conference

Dr. Mohammad Raoufi took home the People's Choice Award for best poster at the annual COAA Best Practices Conference, which took place on May 8–9. Attendees of the conference voted on which of six posters showcasing student research they believed to be the best in terms of technical merit, industry applicability, and quality of presentation. Mohammad's poster summarized the research he conducted as a PhD student on "Assessing the Effect of Motivation on Construction Crew Performance."

On his poster, Mohammad detailed the background and objectives of his research and provided several figures explaining how he developed a fuzzy agent-based model of construction crew motivation and performance designed to help practitioners predict and improve crew motivation. Through his research process, he identified critical factors and practices for enhancing labour motivation, which led to the development of tools for improving performance on construction projects. More information on Mohammad's research can be found on the IRC website at uab.ca/stratcon.

Congratulations Mohammad!



Larry Staples (right) presents Dr. Mohammad Raoufi with the People's Choice Best Poster Award.

Sarah MILLER

## Student Awards

Congratulations to students affiliated with the NSERC Industrial Research Chair in Strategic Construction Modeling and Delivery who have received awards over the past year—they are well deserved!

- Dr. Mohammad Raoufi (former PhD student and current postdoctoral fellow) received the 2017 Ledcor Graduate Scholarship in Construction Engineering and Management.
- Nasir Siraj (PhD candidate) received the Joseph D. Thompson/Zurich Canada Graduate Award in Construction Engineering and Management.
- Sydney Tarrabain (undergraduate student) received the NSERC Undergraduate Student Research Award.