IRC KeyNotes

STRATEGIC CONSTRUCTION MODELING AND DELIVERY
INDUSTRIAL RESEARCH CHAIR

Aminah Robinson Fayek, PhD, PEng
NSERC Industrial Research Chair in Strategic Construction Modeling and Delivery
Professor, University of Alberta

INDUSTRY PARTNERS

Capital Power Corporation

Christian Labour Association of Canada (CLAC)

Construction Owners Association of Alberta (COAA)

Electrical Contractors Association of Alberta (ECAA)
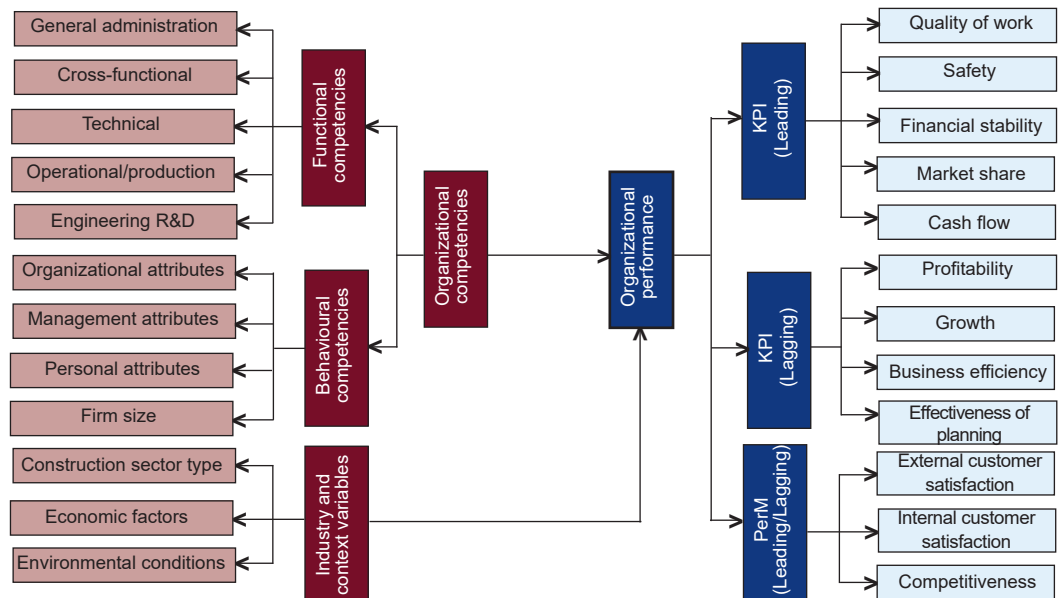
Progressive Contractors Association of Canada (PCA)

Suncor Energy Inc.

Alberta Roadbuilders and Heavy Construction Association (ARHCA)

Merit Contractors Association

nserc CRSNG

Project special feature:
Identifying construction organizational competencies and performance

Organizational competency-performance relationship framework

UNIVERSITY OF ALBERTA/ **GETANEH TIRUNEH**

The IRC is currently conducting a study on organizational competencies and their impact on performance at both the organizational and project levels. With supervision from Dr. Aminah Robinson Fayek, this project is led by IRC PhD student Getaneh Tiruneh and represents an extension of the work done by PhD graduate and former postdoctoral fellow Dr. Moataz Omar during the 2012-2016 IRC term.

The construction industry is characterized by a dynamic, uncertain, and highly complex environment. The industry has also long been criticized for lagging performance. In recent years, organizational competencies research has garnered growing interest, especially in domains such as business and psychology. Competencies at all levels of analysis (i.e., competencies from the activity level all the way up to the organizational level) have a direct and significant impact on construction performance, though further investigation is required by researchers in this domain to resolve a number of fundamental issues. Tiruneh and Fayek (2017) suggest that the construction literature demonstrates misconceptions surrounding the very concept of organizational competency, and it shows substantial inconsistency in the definitions used by researchers.

For example, research in this area tends to focus on evaluating the skills possessed by individual employees, yet such analyses often fail to capture the performance of an organization as a whole. Moreover, the literature does not offer a clear distinction between organizational competencies and performance measures; organizational competencies have occasionally (and mistakenly) been used by researchers as performance measures. Overall, the literature lacks a detailed discussion on the relationship between the two concepts. Tiruneh and Fayek (2017) propose a definition of organizational competency as "an integrated combination of resources, particular sets of skills, necessary information, technologies, and the right corporate culture that enable an organization to achieve its corporate goals, competitive advantage, and superior performance".

The main objective of the IRC's study is to develop a model that uses fuzzy logic, machine learning, and other artificial intelligence techniques, which will allow researchers to measure and quantify sets of different competencies at the organizational and project

Message from the Chair:
Exploring project progress and new developments in IRC year one

Donadeo Innovation Centre for Engineering (ICE), home of the NSERC Industrial Research Chair in Strategic Construction Modeling and Delivery.
UNIVERSITY OF ALBERTA/ **CASSANDRA OMMERLI**

*Please note that these studies are on-going, and the IRC is still recruiting participants to contribute projects for the purpose of data collection and analysis. If your organization is interested in learning more about this research, please contact me at *aminah.robinson@ualberta.ca.*

With seven months of hard work behind us, I would like to provide an update on IRC research projects, touch on some changes in our partnership and in the academic research team, and look ahead to new developments in the months and years to come. Since January, the IRC has made solid progress on its existing research projects. As of summer 2017, we currently have six major projects underway:

Construction productivity analysis and modeling*
Nima Gerami Seresht, PhD candidate:
Having completed an extensive study on labour productivity in the previous 2012–2016 IRC term, we are now focusing on studying the productivity of activities that are more equipment-intensive in nature. We are also examining the relationship between activity-level factors and project-level factors, and their impact on construction project productivity and cost. As this study progresses, a model will be developed that utilizes fuzzy system dynamics to represent the interactions among factors and to predict project productivity and cost under difference scenarios.

Modeling construction crew motivation and performance*
Mohammad Raoufi, PhD candidate:
Through this study, we are examining the relationship between factors that affect the motivation of workers and construction crews, project situational and contextual factors, and crew performance metrics. We will be modeling construction crew behaviour using agent-based modeling to determine group dynamics and their impact on crew performance.

Capital project productivity and effectiveness
Selam Ayele, MSc candidate:
This research is exploring the development of a high-level metric on capital project productivity and effectiveness. Eventually, the IRC will create a model that will help to identify the factors affecting capital project productivity and to gauge their relative impacts on overall project effectiveness.

Construction organizational competencies and performance*
Getaneh Tiruneh, PhD student:
The goal of this study is to develop a model for measuring and quantifying competencies at the construction organizational level, as well as their impact on construction organizational performance. See page 1 for our special feature on this project.

Risk analysis and modeling
Nasir Siraj, PhD candidate; Natalie Monzer, MSc candidate:
During the previous 2012–2016 IRC term, we developed Fuzzy Contingency Determinator© (FCD©), a software tool for risk analysis that allows practitioners to make use of their expertise to analyze risks and opportunities and to mathematically calculate how much contingency to build into a project. When FCD© was first developed, it required companies to bring together a group of experts to reach consensus on the probability and impact of each risk and opportunity factor. Research being conducted by Natalie Monzer will soon allow FCD© users to assess risk and opportunities independently, which will be aggregated into a final contingency value, while accounting for each expert's level of expertise in risk analysis. In addition, Nasir Siraj is currently applying fuzzy system dynamics to model the dynamic project risk environment so that the impact of risk mitigation strategies can be assessed in real-time.

Advanced Work Packaging (AWP) and WorkFace Planning (WFP)
Yonas Halala, MSc candidate:
This research is developing a framework for measuring both the costs and benefits of implementing AWP and WFP on industrial construction projects. The maturity of AWP practices and other factors affecting the effectiveness of AWP, such as the qualification of WorkFace planners, foremen, and crews implementing AWP, are also being examined.

During the past year, the IRC was fortunate to have the opportunity to showcase this research at several major industry and academic events, including the 2017 Construction Owners Association of Alberta (COAA) Best Practices Conference and the 2017 Canadian Society for Civil Engineering (CSCE) Annual Conference (see page 5 for more information). Participation in the larger industrial and academic communities remains an important component of the IRC's commitment of contributing to the advancement of the construction profession through facilitating knowledge and technology transfer across industry and academia. Moreover, our participation in these events allows us to better understand the needs and perspectives of the wide variety of organizations and personnel that contribute to the success of the construction industry.

In addition to discussing our research, I would like to draw attention to some of the changes that have occurred within our program in terms of our people and partner organizations. In January 2017, the IRC welcomed new full partner, the Electrical Contractors

Message from the Chair

Association of Alberta (ECAA), represented on the management advisory committee by Brian Halina (chair of labour relations at ECAA and president/chief executive officer at Chemco) and represented on the technical advisory committee by Jim Bendfeld (labour relations coordinator at ECAA). Also joining the IRC is new associate partner, the Alberta Roadbuilders and Heavy Construction Association (ARHCA), represented on the management advisory committee by Jim Rivait (chief executive officer at ARHCA) and represented on the technical advisory committee by Heidi Harris-Jensen (director of external affairs at ARHCA). On the academic side of the group, the IRC saw the addition of four new staff members. Though postdoctoral fellows, undergraduate research assistants, and other support staff members can be less visible to our industry stakeholders than are IRC graduate students, who directly and regularly interact with partner organizations on IRC research, these staff members play distinctive and critical roles in ensuring the progress of research and finalizing deliverables such as software, technical reports, and presentations. On page 4, we interview postdoctoral fellow Dr. Rodolfo Lourenzutti, who brings a rich background in statistics and computer science to his work with the IRC. In addition, we also introduce you to Sarah Miller, our new technical writer and point of contact for IRC stakeholders. I would also like to give a warm welcome to our new computer programmer, Andrew Johnston, who has already made significant contributions towards helping the IRC achieve its goal of creating applied practices and industry tools. Moreover, the IRC would like to thank engineering undergraduate co-op student Eddie (Ming Kit) Yau for his research support over the past three months. Through the NSERC Undergraduate Student Research Award program, Eddie has been assisting the IRC team in a number of areas, including providing data collection support to Yonas Halala for his AWP study and assisting Mohammad Raoufi and Nima Gerami Seresht in completing data entry and analysis for their respective research projects.

As our team continues to grow and evolve, so too must we bid farewell to some of our valuable members. I would like to express my gratitude for the contributions made by our former 2012–2016 IRC term partners: Aecon, Building Trades of Alberta, and TransAlta. Thanks go out also to our former undergraduate programmer Ramandeep Dhatt for her outstanding contributions towards the development of IRC software. Finally, I would like to give my sincere thanks to former technical writer Cassandra Ommerli for the writing, editing, and presentation support she has offered to IRC

team members over the past two years, and for providing essential communications and administrative support to the program and its stakeholders.

Looking to the latter half of 2017, the IRC will soon see many of its current student researchers defending their theses and completing their respective academic programs. On the other hand, we will also be welcoming a number of new graduate students for fall 2017. Graduate students play a critical role in IRC research by carrying out data collection and analysis with our partner organizations, and by developing the cutting-edge academic work that creates innovative applications for our industry

University of Alberta faculty members Dr. Robinson Fayek, Dr. AbouRizk, Dr. Pedrycz, and Dr. Zuo will investigate methods to support the construction and maintenance of non-electrical infrastructure for Future Energy Systems research.

PIXABAY

partners. Bringing on new graduate students is crucial to ensure the continuity of our projects over the course of the IRC term. Beyond the IRC, I am also undertaking some new collaborative research engagements. Through the University of Alberta's $75M Future Energy Systems (FES) program, which was established through the Canada First Research Excellence Fund, we have received funding to carry out research related to the FES's non-electrical infrastructure theme over a six-year term from 2017 to 2023. I will be collaborating on FES research with fellow Faculty of Engineering professors Dr. Simaan Abourizk (Department of Civil and Environmental Engineering, Hole Science of Construction Engineering), Dr. Witold Pedrycz (Department of Electrical and Computer Engineering), and Dr. Ming Zuo (Department of Mechanical Engineering). In order to effectively harness energy sources and make them available to consumers, extensive infrastructure for energy extraction, processing, refinement, and delivery must be constructed and continuously maintained. These construction and maintenance projects

require proper planning and execution to reduce risks and uncertainty. Our FES research will complement the work done by the IRC by exploring innovative modeling and decision-making approaches capable of handling unique project characteristics, risks, and data limitations.

In regards to the future trajectory of our research program (including the IRC and beyond), we will continue to bring some of our fundamental research closer in line with the federal government's goal of driving investment and job creation through the advancement of research and development (R&D) initiatives, particularly those focused on artificial intelligence and machine uncertainty. By combining fuzzy logic with other artificial

intelligence techniques, particularly machine learning, we can greatly enhance the capabilities of existing methods and equip them with the ability to learn from data. As many of you may be aware, this past March, the Government of Canada announced its plan to invest $125 million in a Pan-Canadian Artificial Intelligence (AI) Strategy, which will be administered by the Canadian Institute for Advanced Research (CIFAR). This decision is intended to support Canada in establishing the nation's reputation as an international leader in AI research and training.

The Pan-Canadian AI strategy will also support the development of three centers of innovation within the country, which will be based in Toronto, Montreal, and here in Edmonton. These centres of innovation help to support research excellence through facilitating dynamic scientific networks across industry, government, and academia. From changes in our partnership to new developments in the policies that influence Canadian R&D, I look at each change as an opportunity to deliver value to new stakeholders and to ensure the advancement and evolution of our IRC program. ∎

Introducing Dr. Rodolfo Lourenzutti

Dr. Rodolfo Lourenzutti, IRC postdoctoral fellow

UNIVERSITY OF ALBERTA/ **CASSANDRA OMMERLI**

With a broad range of experience in computational intelligence, Postdoctoral Fellow Dr. Rodolfo Lourenzutti has demonstrated himself to be a vital asset to IRC research. Originally from Vila Velha, a coastal town in Brazil, Dr. Lourenzutti completed his PhD in computer science from the Federal University of Espirito Santo in 2016. Prior to his doctoral studies, he also completed a Bachelor of Science in statistics at the Federal University of Espirito Santo, as well as a Master of Science in statistics from the Federal University of Minas Gerais. As a PhD student, Dr. Lourenzutti worked with group multicriteria decision making (MCDM) problems, where achieving consensus was not a requirement. During the third year of his PhD, he accepted the opportunity to participate in a sandwich program, which brought him to the University of Alberta to work under the supervision of Department of Electrical Engineering Professor Dr. Marek Reformat. Over the duration of the 10-month program, Dr. Lourenzutti investigated the development of MCDM techniques to allow a group of decision makers to consider different sets of criteria, weight values, and types of data, as well as criteria interactions in dynamic and random environments.

Dr. Lourenzutti's expertise in MCDM has greatly served to enrich IRC research. For example, since joining the team in March 2017, Dr. Lourenzutti has been providing ongoing support to MSc candidate Natalie Monzer, who is exploring methods for aggregating the opinions of multiple experts with differing levels of expertise in MCDM problems related to risk analysis. Dr. Lourenzutti notes that MCDM has a great deal of applied value within the construction industry: "Reaching consensus among experts can be a biased process, with one person dominating the discussion, plus it can be very time consuming. As researchers, our ultimate goal is find techniques that offer more freedom to experts in providing their evaluation." Dr. Lourenzutti is particularly interested in exploring new ways to represent and process expert knowledge. "I am very fascinated by the research that goes into building models that use a combination of expert opinions and objective data in order to predict outcomes like performance, cost, and risks," he remarks.

As a postdoctoral fellow for the IRC, Dr. Lourenzutti supports Dr. Robinson Fayek through providing additional technical guidance and research support to graduate students on their presentations, papers, and theses. During his doctoral studies, he frequently acted as a lecturer at the Federal University of Espirito Santo, teaching courses such as introductory programming in C to physics and engineering students. Moreover, with a quantitative background in areas including statistics and computer science, he has also been able to offer the IRC team a different perspective on data modeling.

This insight has been particularly useful in helping Dr. Robinson Fayek and her research team to develop rigorous research plans for grants and proposals: "I cannot emphasize enough the value that team members like Dr. Lourenzutti bring to the table. His fresh perspective allows us to critically assess our research challenges from a different vantage point, which often results in the development of new and more dynamic solutions."

Of his experience so far at the University of Alberta, Dr. Lourenzutti remarks that "the postdoctoral fellow role has provided me with an excellent opportunity to expand my research record, while gaining the sort of mentorship I need to someday transition into a professorial position. I am very grateful not only for the unique research opportunity I have received through my participation in the IRC, but also for the guidance I have received from Dr. Robinson Fayek." ∎

Welcome Sarah Miller

Sarah Miller, IRC technical writer

UNIVERSITY OF ALBERTA/ **CASSANDRA OMMERLI**

The IRC is pleased to introduce its newest member, Sarah Miller, who joined the research team as technical writer in June 2017. Sarah brings to the program over seven years of experience in writing, editing, and research, and has worked in a diverse range of professional contexts, including media and information services and the not-for-profit sector. Sarah received both her Bachelor of Arts and Master of Arts degrees in English literature from Trent University, and she is excited to return to an academic setting and work with graduate students on their writing. Moreover, Sarah brings an understanding of the graduate experience that will inform her editorial relationships with those students.

Following the completion of her master's degree, she worked for two years as an editorial assistant with JuneWarren-Nickle's Energy Group (JWN), a digital and print magazine publisher and intelligence provider. Most notably, Sarah worked as editorial assistance team lead for the Oilfield Atlas digital and print publication, a comprehensive guide to oil and gas pipelines and facilities across western Canada. She consulted with managers across several departments and coordinated logistics on a condensed production timeline, bringing the project to completion ahead of schedule.

Keen on challenging her instructional and editing skills in a new environment, Sarah accepted a volunteer role with Cuso International to teach English to government personnel in the Myanmar Parliament and the Department of Rural Development. She leveraged her flexibility to instruct a diverse group of students with a wide variety of needs, from improving grammar, to giving presentations, to arguing effectively. In addition, Sarah wrote the closing speech for the 37th General Assembly of the Association of Southeast Asian Nations (ASEAN) Inter-parliamentary Assembly.

Event recap:
2017 Canadian Society for Civil Engineering (CSCE) Annual Conference

Coal Harbour in Vancouver, BC

PIXABAY

This past May, Dr. Robinson Fayek and three of her graduate students, Getaneh Tiruneh (PhD student), Selam Ayele (MSc candidate), and Natalie Monzer (MSc candidate), traveled to Vancouver, BC to present papers at the 6th Canadian Society for Civil Engineering (CSCE)/Construction Research Council (CRC) International Construction Specialty Conference. The specialty conference is a component of the CSCE's annual conference, which covered "leadership in sustainable infrastructure" as this year's theme. References are provided below for each of the papers presented by IRC team members at the specialty conference:

Ayele, S., and Fayek, A. Robinson. (2017). Framework for measuring overall productivity in construction projects. *Proceedings, Canadian Society for Civil Engineering (CSCE) 6th International/12th Construction Specialty Conference*, Vancouver, BC, May 31-June 3: CON-015-1–CON-015-10.

Tiruneh, G.G., and Fayek, A. Robinson. (2017). Identifying construction organizational competency measures and performance indicator metrics. *Proceedings, Canadian Society for Civil Engineering (CSCE) 6th International/12th Construction Specialty Conference*, Vancouver, BC, May 31-June 3: CON-016-1–CON-016-10.

Monzer, N.I., Siraj, N.B., and Fayek, A. Robinson. (2017). Evaluation of heterogeneous levels of expertise in expert risk assessment in construction. *Proceedings, Canadian Society for Civil Engineering (CSCE) 6th International/12th Construction Specialty Conference*, Vancouver, BC, May 31-June 3: CON-017-1–CON-017-10. ∎

Event recap:
2017 Construction Owners Association of Alberta (COAA) Best Practices Conference
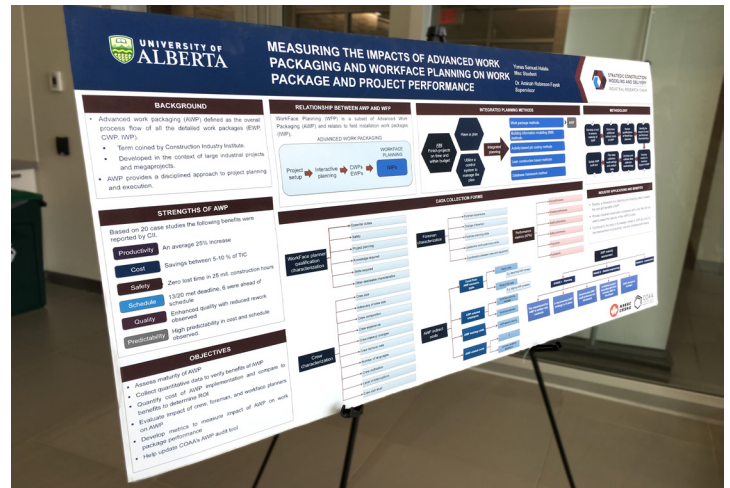
Student poster competition

The IRC academic team would like to express its gratitude to the Construction Owners Association of Alberta (COAA) for the opportunity to showcase research in yet another valuable and informative annual Best Practices Conference. Held May 9th-10th, 2017 in the Shaw Conference Centre in Edmonton, AB, this past year marked the 25th anniversary of the event. Since 2000, Dr. Robinson Fayek and her research team have participated in the COAA Best Practices Conference in some capacity. For the 2017 event, seven of Dr. Robinson

Fayek's graduate students presented posters covering their progress on various IRC projects. Special mention goes out to MSc candidate Yonas Halala for his winning entry in the student poster competition: "Measuring the impacts of advanced work packaging (AWP) and workface planning (WFP) on work package and project performance". One-page research summaries of student posters developed for the 2015-2017 conferences can be found on the IRC website *www.strategic-construction.ualberta.ca*.

Workshop session

In concert with collaborators from the COAA, Tannis Liviniuk and Ryan Posnikoff, Dr. Robinson Fayek also hosted a workshop session on day two of the event to discuss its study on the topic, "Measuring the impacts of advanced work packaging (AWP) and workface planning (WFP) on work package and project performance". Critical contributions to the research and presentation were also made by Yonas Halala (MSc candidate) and Nima Gerami Seresht (PhD candidate). During the session, the hosts discussed the industry need for quantifying the costs and benefits of implementing AWP, in addition to presenting an approach for measuring all factors impacting AWP costs and benefits. ∎

Winning student poster competition submission by Yonas Halala

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Welcome Sarah Miller

During this time, Sarah also began a freelance editing and writing business, providing substantive editing for a wide range of texts, including fiction, memoirs, screenplays, and academic writing. She found the experience of living abroad stimulating and enjoyable, and embraced the challenge of adapting to a different culture and climate.

Despite being such a new addition to the team, Sarah has gracefully handled the learning curve that come with taking on a project involving abstract and technically dense writing. "Sarah has already demonstrated a real aptitude for high-level editing," remarks Dr. Robinson Fayek, "As an editor, her precision and attentiveness to detail are commendable." As for her outlook on her new role, Sarah expresses enthusiasm at the prospect of immersing herself into the field of engineering research. "I am very excited to be learning about the applications of fuzzy hybrid modeling techniques in the construction industry as I work with researchers to present their findings in the clearest and most concise manner possible," Sarah notes, "I look forward to continuing to increase my knowledge of this field and to tackling the challenges of editing scientific writing in an academic-industrial setting." ∎

Project special feature

levels. In turn, this model will provide a means to evaluate the impact of organizational competencies on performance at the organizational and project levels in terms of various key performance indicators (KPIs). The study began with the development of a list of organizational competency measures and performance indicator metrics, as well as a framework to establish the competency-performance relationship. As the project progresses, this framework and list will be verified through focus group sessions conducted with industry experts and then adjusted by researchers based on the feedback received. Following the verification process, data will be collected from a range of organizations in the construction sector in order to evaluate different organizational contexts. Next, researchers will develop the aforementioned model, which will later be validated through feedback from industry experts.

The resulting model will be useful in helping construction decision makers to identify organizational competencies leading to improved performance and competitiveness. This research will also provide practitioners with a systematic process for measuring and enhancing competencies at the organizational and project levels. In addition, findings from this project will shed insight on how organizational leaders can improve organizational and project practices to maximize their performance and competitive advantage. ■

Tiruneh, G.G., and Fayek, A. Robinson. (2017). Identifying construction organizational competency measures and performance indicator metrics. Proceedings, Canadian Society for Civil Engineering (CSCE) 6th International/12th Construction Specialty Conference, Vancouver, BC, May 31-June 3: CON-016-1–CON-016-10.

CONGRATULATIONS

HSCE Graduate Student Awards

Congratulations go out to the successful recipients of the Hole School of Construction Engineering 2017 Graduate Student Awards, with special acknowledgement given to IRC- and IRC partner-related award recipients:

- **Mohammad Raoufi** (PhD candidate, supervised by Dr. Robinson Fayek): awarded the 2017 Ledcor Graduate Scholarship in Construction Engineering and Management

- **Nasir Bedewi Siraj** (PhD candidate, supervised by Dr. Robinson Fayek): awarded the 2017 Ernie Tromposch Graduate Scholarship

- **Estacio Pereira** (PhD candidate, supervised by Dr. Abourizk): awarded the 2017 Glen Warren Graduate Scholarship ■

Don Currie Award of Recognition

Brad Anderson, recipient of the 2017 Don Currie Award

COAA

The IRC in SCMD would like to acknowledge the achievements of Brad Anderson, successful recipient of the Don Currie Award of Recognition:

"Named to honour D.V. (Don) Currie, P. Geol., who served as the third Managing Director of COAA from 1985 to 2000, the COAA presents this award annually to recognize those individuals whose long-standing and dedicated service has contributed to the success of the COAA."

Over the years, Brad has been instrumental in facilitating an effective relationship between the IRC in SCMD and the COAA, and the guidance and mentorship he has provided to the program are greatly appreciated. Brad is now working as an advisor in the Faculty of Engineering Dean's Office. In the coming months, Brad will also be working with Dr. Robinson Fayek to spearhead the Faculty of Engineering mentorship program for its faculty members. ■