Challenges and Opportunities for Modular Construction in Canada

Workshop Summary Report

October 29-30, 2015

Hosted jointly by Concordia University and the Modular Building Institute

in collaboration with Canadian Construction Innovations and the University of Alberta

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1.0 EXECUTIVE SUMMARY

The on-site building method currently prevalent in construction is laden with issues such as inefficiency, resource waste, a large carbon footprint, and health related issues for workers and nearby residents. The processes employed limit productivity improvements and opportunities for innovation in construction. Industrialization of the building process, referred to here also as modular or offsite construction, reduces cost, construction time, and waste. It is also capable of improving productivity, quality, and safety on construction jobsites.

Although the industrialized building approach may be beneficial to many entities, including owners (private and public), institutions responsible for schools and hospitals, general contractors, and architectural/engineering organizations, the adoption of this approach, in particular in publicly funded building, is limited due to several issues, such as the following:

1. Negative stigma: There is a negative stigma associated with modular and offsite construction, as well as misconceptions that modular construction is of lower quality and is intended primarily for temporary, single-storey buildings.
2. Shortage of examples of past success: There is a lack of evidence and awareness of successful implementation of modular construction utilizing mixed use of concrete, steel, masonry, and wood for mid-rise and high-rise building projects.
3. Standards and regulations: The existing building code, bylaws, and operational standards are systemically more conducive to conventional construction practices.
4. Procurement strategies that favour conventional construction technologies: At present, the dominant practice for public procurement is for projects to be awarded to the lowest bidder. A value-based system for procurement may create new opportunities for modular construction, which provides advantages that conventional construction cannot offer.
5. Project financing: Current practice involves progress-based financing of projects, which inherently favours conventional construction: Public project owners recognize that modular builders will invest significant resources on a product upstream prior to onsite assembly (i.e., when the product is still in the factory or in storage, thus creating a cash flow challenge under the current system), and poses the need to restructure project financing and streamline cash flow for publicly-funded projects to enable the use of modular.

More communication and collaboration is needed in order to overcome these obstacles. In recognition of this need, Dr. Osama Moselhi, of Concordia University, alongside the Modular Building Institute (MBI), and in collaboration with the University of Alberta and Canadian Construction Innovations (CCI), hosted a workshop titled "Challenges and Opportunities for Modular Construction in Canada," on October 29-30, 2015. The workshop was funded by NSERC through its Connect program, and additional sponsorship was provided by Canam Group Inc.

The workshop commenced with a reception and banquet dinner featuring a keynote lecture presented by Dr. Mohamed Al-Hussein, Professor of Civil and Environmental Engineering at the University of Alberta and Industrial Research Chair in the Industrialization of Building Construction. The following

morning opened with a keynote address from Dr. Amir Asif, Dean of the Faculty of Engineering and Computer Science at Concordia University, after which a series of panel discussions began. The first panel to present was comprised of attendees from industry, each of whom spoke briefly on challenges and opportunities that they have observed in their respective sectors in relation to modular construction. The second panel was academic, and members presented and discussed their research and how it relates to challenges and opportunities in offsite construction.

The panel discussions wrapped up with an open question and answer period, which was then followed by lunch. During lunch Steven Williams, Operations Director of MBI, and partner in the workshop, spoke regarding the work of MBI and efforts to promote the modular industry.

Following the luncheon, session attendees were divided into five groups and were given specific topics for a round-table discussion. After an hour of problem-solving and dialogue, each table in turn presented the results of their analysis. Once each group had shared their efforts, an open discussion between attendees took place, until the workshop concluded.

2.0 KEYNOTE ADDRESS: Dr. Mohamed Al-Hussein

Dr. Mohamed Al-Hussein is a professor and Industrial Research Chair (IRC) in the Industrialization of Building Construction at the University of Alberta, and was recently appointed Director of the newly established Nasseri School of Building Science and Engineering. He is a recognized leader in modular construction and a highly sought researcher and consultant in the areas of lean manufacturing, construction process optimization, CO_2 emission quantification, and building information modelling (BIM), with the development of modular and offsite construction technologies and practices forming the hub of his research. Dr. Al-Hussein's research has developed best practices for panelized building systems, lean production, and modular construction. He presented his utilization of modular construction to build five 3-storey student dorms at a Pennsylvania college in just 10 onsite working days. Dr. Al-Hussein highlighted examples of his applied research in the area of modular and offsite construction, including several mid-rise multi-family residential facilities, such as a 68-unit apartment building for which on-site assembly of modules was completed in just two days. He briefly presented his recent experience with Alberta Infrastructure and the difficulties encountered in the preparation of a request for proposals related to modular construction and how it could allow for good number of bidders and help achieve owners specified needs. Dr. al-Hussein shared the early findings of a recent workshop held for that matter.

Dr. Al-Hussein's IRC focuses primarily on seven research objectives:

i. Improve construction productivity through innovative manufacturing technologies.

ii. Improve the productivity of design and drafting for manufacturing (DDFM) that encompass the integration of the design process and the machine language.

iii. Develop mathematical algorithms to optimize material usage and minimize waste.

iv. Quantify and minimize CO_2 footprint of the construction process.

v. Assess occupational health and indoor air quality in order to control and mitigate risk.

vi. Improve urban design and planning.

vii. Develop a BIM-based planning process to minimize rework and material and process waste.

He also pointed out that his research is conducted in conjunction with several industry partners, providing new and innovative solutions to real-world issues, and significantly advancing the state of the modular and off-site construction industry within Canada.

The Keynote address of Dr. Amir Asif, Dean of Engineering and Computer Science at Concordia University was delivered in the morning of the following day.

Amir Asif is Dean of the Faculty of Engineering and Computer Science at Concordia University and professor with the Department of Electrical and Computer Engineering. An emerging voice among engineering leaders, Dean Asif is rethinking how to unlock the full potential of the engineering

profession through academic innovation and by addressing the systemic issues that have been holding it back. He stressed how modular construction can be of help not only for expanding the global market for Canadian construction but also to the development of the Canadian north. More details are included later in Section 6.

3.0 Panel Discussions

Panelists were invited to make a ten to fifteen minute presentation highlighting issues pertaining to efficient utilization of modular construction within their respective areas of expertise, speaking to opportunities that are available, and difficulties that currently exist. The panelist presentations were followed by questions and focused discussions.

3.1 Industry Panel Discussion

The industry panel presentations represented the organization of construction project stakeholders: owners, architects, engineers, fabricators, and contractors, respectively. Gilles Bernardin, Site Manager for Defence Construction Canada (DCC) on the Canadian Forces Base at Petawawa represented owners, and was followed by Martin Tite, a Principal at GRC Architects, speaking as an architect and designer. Representing fabricators was Laurie Roberts, Vice President of Sales and Marketing at NRB Off-Site Construction; following her, from the perspective of fabricators and constructors, was Tony Begin, Senior Director of Integrated Project Delivery (IPD) from Canam Group Inc.; and finally, Peter Lister, Vice President of Forest Operations and Wood Products at FPInnovations, spoke as a supplier.

Speaking from the perspective of the owners (whom DCC represent), Mr. Bernardin cited a series of successful modular projects that were implemented at the Canadian Forces base in Petawawa. A new program at the base demanded an increase in housing, and DCC responded by bringing in 68 modular units comprising duplex and four-plex residences. The project was delivered without changes, on time, and the client is overall very satisfied with the results. The Forces base also uses modular construction for temporary office space projects, and a complex for dental and health facilities. These projects follow the design-built project delivery system, allowing DCC to provide a data sheet and performance criteria, and then the modular companies continue the project on to completion. Modular has been used on the base for similar projects for approximately ten years; however, there are difficulties that prevent the expansion of modular as a solution for customized and more complex projects, which comprise a much larger portion of new construction on the bases.

One difficulty is the existing financial structure. Typically, there is a budget given that must be completely used up within a calendar year, which usually works to the advantage of modular projects where there is many of the same kind of unit; however, all DCC projects require a competitive bidding process. This competitive bid must have multiple local manufacturers, which are not readily available, and an architect must also create a standard on-site/stick-built spec in order to compare modular manufacturers. Another financial difficulty is due to public projects requiring a highly detailed financial breakdown—to within ten percent of the total cost of each line item, which is problematic for customized offsite work.

The largest challenge for Canadian Forces public projects is security requirements. The guidelines for construction near an operational zone are very strict; for example, the entire facility must be built by security-cleared workers. For factory construction, this potentially means security clearing all employees, as well as full plant inspections. These requirements may create huge delays in project delivery—not possible with the budget turnaround requirements.

A question for the panel was raised about whether the choice to look at modular as a potential answer for DCC project needs was generated by the owners, or architects and industry, etc. Mr. Bernardin replied that unless representatives of the owners (or the owners themselves) request modular, it is not provided as a solution, perhaps because the industry lacks required expertise.

Martin Tite (GRC Architects) presented a design and architecture perspective, speaking as someone who has used modular and offsite construction in a few instances, but more typically works within conventional construction methods. He presented a brief historical survey of important architectural works that were modular or offsite in nature—beginning more than 150 years ago. This longstanding use of modular and offsite construction implies that there are no glaring inherent technical obstacles preventing its use as a popular building method, so the difficulty probably lies in culturally embedded issues.

Part of the issue is that modular construction is often viewed as being in competition with conventional construction. The two systems of construction have their own best fit applications, but currently the industry is biased towards conventional construction, and from a design perspective this is partly because it is scalable, works with almost all supply chains, and is completely customizable and compatible with renovation and addition. The reason that typical on-site construction is so versatile and prevalent is largely due to the fact that it is in such high demand compared to the demand for modular construction—if the market were to change so that modular were more popular, it can be assumed that suppliers and trades would fill in the gaps.

Issues that must be addressed include the education of designers, engineers, and trades so that modular and offsite emerges as a potential choice. Also, modular construction as it exists may be an impediment to renovation and addition, for example when the engineered modular system cannot take on any load, or when additions are limited to the same suppliers or highly custom pieces.

There are many opportunities, however, as modular has in the past been a driver of the aesthetics of a building and can be used in situations when a conventional method of construction is not possible due to time or location constraints, etc.

Following Martin was Laurie Robert, Vice President of Sales and Marketing at NRB Inc., a modular building design and construction company based out of Ontario.

At present, the largest opportunity for the modular construction industry is to increase market share. In the commercial construction industry, modular construction currently represents only 2.34% of the total market. The National Institute of Building Sciences (NIBS) began an offsite construction council in 2013 in response to this disparity, and conducted a survey in order to rate the barriers that hinder the implementation of offsite construction. The barriers were determined as follows:

1) Design and construction culture

2) Distance from factory to site (because transportation greatly increases cost)

3) Lack of knowledge about modular in the construction industry

Transforming perceptions of modular construction is vitally important in order to increase the market share. The general public tends to associate modular construction with only temporary buildings, e.g., trailers, and there must be an increased understanding that modular construction is a method that can produce equally excellent permanent structures.

A key to the success of modular construction projects is project integration, with cooperation from all stakeholders, including owners, design professionals, construction managers, and general contractors, etc. The modular process requires buy-in and understanding from all parties at an early stage because it differs from conventional construction, for example, in scheduling, sequencing, and scope. On projects, the modular company must be engaged up front in order to educate all parties about the process, and bring an understanding of the issues that are unique to modular construction such as the order of assembly, moving fabricated modules, and that the footprint of the modules must be decided and designed very early, etc.

Other hurdles to the adoption of modular construction include financing structures (for example, is a module property or equipment?), as well as shipping of the modules. Transportation is a presently a large hurdle as it restricts the modules in terms of width, height, structure, and weight, it also depends on site access, and can comprise a large portion of the budget.

A very important message that must be communicated is not only the availability of modular solutions for permanent structures, but also the need to engage modular companies and all parties early in the process, to protect against scope gaps or creep, and for all roles and responsibilities to be communicated clearly.

Tony Begin spoke from the perspective of a fabricator and lead constructor, as the Senior Director of IPD of Canam Group Inc., a large steel fabrication company.

A past project that successfully utilized the modular system was presented in order to demonstrate how modular construction addresses inefficiencies that are common in conventional construction; for example, there are far fewer people required on-site during assembly, and the schedule can be much tighter.

Canam’s experience working with modular and the construction industry led them to change their strategy away from marketing a product to marketing a range of preconstruction services. This involves meeting owners very early in the process and promoting an integrated project delivery process. It is just as important to sell the process of modular construction as it is to sell the modules.

Part of this shift from promoting a product to promoting an integrated service involves finding tools and technologies that support this process. Canam uses virtual construction models and BIM modelling as part of the integrated services they provide, and are cultivating an expertise in these areas in order to augment the process and add value for clients.

Peter Lister, Vice President of Forest Operations and Wood Products at FPInnovations, was the final industry panelist. FPInnovations is a private, not-for-profit organization with a mandate to support the advancement of technology in the wood sector and promote research by bringing together industry, government, and academia. They also work to bring new products to market, and to change legislation,

such as height restrictions on wood buildings and increasing the number of applications available for forestry products.

FPInnovations works to develop new products and techniques by working in conjunction with both government and private sector companies. Working cooperatively with legislative bodies to change regulations is essential, and has allowed the wood industry to expand into new areas; for example, code restrictions for allowable heights in wooden buildings has changed from four to six storeys after research findings were presented to governing bodies, and now the number of wood-framed six-storey buildings has greatly increased.

New opportunities for modular construction are available, and will continue to increase with more research, communication, and advocacy.

3.2 Academic Panel Discussion

The academic panelists assembled from universities across Canada and the United States, and represented a wide scope of research applications related to the modular building industry, from residential offsite construction, to production and onsite assembly, to project delivery systems, to offshore heavy industry, to automation in construction progress tracking. The presenters were asked to discuss their work, and share their views on the industry collaborative research necessary to help advance modular construction. The academic panelists were: Dr. Neil Eldin, Professor and Chair of the Department of Construction Management from the University of Houston; Dr. Jeff West, Associate Professor from the University of Waterloo; Dr. Raymond Issa, Professor and Director, Center for Advanced Construction Information Modeling, University of Florida; Dr. Simaan Abourizk, Professor and Industrial Research Chair in Construction Engineering and Management from the University of Alberta; and Dr. Mohamed Al-Hussein, Professor, and Industrial Research Chair in the Industrialization of Building Construction from the University of Alberta.

Dr. Neil Eldin, from the University of Houston, was the first panelist to speak. His research focus has been modular construction in offshore oil and gas projects, where the offsite process has been employed for decades. There are key lessons to be learned from offshore construction, as there have been roughly three iterative generations of modular used in oil and gas.

The first generation of modular consisted of basic components, such as simple modules, pipe racks, and other structural elements. From there the industry progressed to add some equipment to the module, and preassemble units. The third, and current generation of this offshore construction involves designing the modules around the equipment, and shipping largely completed units to site. The majority of piping and insulation are installed, and some electrical and instrumentation equipment are in place before the modules leave the factory.

This process can be learned from and implemented in on-shore modular construction as well, as there are parallels with HVAC equipment and the oil and gas equipment, which can be designed and integrated into the module from the start, and the lack of concrete foundations in some offshore projects demonstrates innovative structural solutions that can be employed.

Challenges currently faced by the modular industry mirror the challenges that the offshore industry has encountered in the past such as a lack of integrated design processes, costly logistical problems, etc. The on-shore modular industry should look to offshore and heavy industry for potential solutions.

Dr. Jeff West, professor at the University of Waterloo, spoke regarding his research in automated construction progress tracking and tolerance detection.

The challenges that modular construction is currently facing include the impediments to innovation presented by existing standards and regulations, which are biased toward conventional construction methods. There must also be an increase in coordination between the design, engineering, and fabrication sides of projects, which is currently not the industry standard. Another major factor is that transportation and handling can greatly influence the loads that modules encounter, meaning that the module must be designed properly from the outset.

The research being done at the University of Waterloo involves a number of initiatives: tolerance management, and integrating tolerance controls in manufacturing and construction; risk-based analysis and decision strategy for project planning; and, the development and use of 3D imaging technologies. The manufacturing industries that lie outside of construction (e.g., automotive, etc.) tend to have very highly developed tolerance management systems, often utilizing the concept of inverse kinematics, a technique utilized in Dr. West’s research. The modular construction industry may look to these other industries for such systems to apply to offsite construction. The research goal is to develop processes that will allow realistic levels of tolerance to be incorporated into modular construction manufacturing practice by first identifying the types of tolerances and then establishing the relationships between fabrication cost and project risks, and coming up with a problem solving strategy.

This type of research is vital for the modular construction industry to control cost by optimizing the fit of imperfect modules or assemblies, engineering tolerance controls for both the final assembly and the transportation of parts, and to design connections that balance the efficiency of construction with structural requirements. The research incorporated a framework for tolerance accumulation and the characterization of risks specific to modular construction, in order to find the optimal tolerance for modules. Using 3D scanners, the researchers compare built modules with their digital designs, and then conduct comparison analysis to understand deviations in the built structures. Once geometric discrepancies between designed and built components are captured, inverse kinematics are employed to develop realignment strategies for corrections. Currently, this technology exists in non-construction manufacturing industries, but could prove useful in offsite projects.

Dr. Raymond Issa, Professor at the University of Florida and Director of the Center for Advanced Construction Information Modeling, spoke on the challenges and opportunities facing modular construction, and his research in manufactured construction methods.

It is vital that all parties involved in the construction process have a thorough understanding of the logistical peculiarities of modular construction in order to have an effective execution plan for prefabricated buildings. These include shipping and hauling, crane erections and labour, waterproofing components, and finishing on-site, and other processes that can differ from conventional construction. These differences require a change in the mindset of involved parties, including whichever authority has jurisdiction, and the owners.

Many of the changes that are necessary for the success of the modular industry occurred in other industries only when there was sufficient market demand. The modular industry, therefore, must create a marketing plan in order to increase demand to the point that it is profitable to undergo the necessary changes.

Dr. Simaan Abourizk, a Professor at the University of Alberta and Industrial Research Chair in Construction Engineering Management, spoke regarding his research experiences with modular construction.

There are examples of very successful modular construction projects in industrial applications in Canada, for example the Diavik Diamond Mine project. One of the reasons that modular was such an ideal solution for the Diavik Diamond Mine project was because there exists no infrastructure on site, which means that all aspects of the project must be planned out in advance, which is easier to control with

factory-based construction. Modular construction has been so successful in applications such as this that Alberta currently has the largest total combined area set aside for modular assembly yards in North America. The popularity of offsite construction in industrial applications has also instigated a lobbying effort on behalf of the modular industry to change load constraints for transportation.

Other applications that have seen huge success with the use of offsite construction, which include automotive and shipbuilding industries, have benefited greatly from the standardization of methods and products. While many projects themselves are custom, there could be a great increase in the number of standards and best-practices used in the field—for example, the use of pipe racks is very widespread, and they all serve roughly the same purpose, but there is little agreement on what exactly this piece of equipment should look like.

Dr. Mohamed Al-Hussein, a Professor at the University of Alberta and Industrial Research Chair in the Industrialization of Construction, spoke regarding the difficulty in bid processes and also the success of factory built-projects.

Alberta Infrastructure (AI), a government body responsible for constructing and maintaining many of the public buildings in Alberta, recently contacted Dr. Al-Hussein to work with them to review their bidding process. AI found that they were only receiving a handful – one or two – eligible bids for some of their large School Board projects, and want a more competitive process. Their bid spec was reviewed and in a collaborative process with local modular building companies problems were identified and suggestions for changes made. The process demonstrated several problems that are common in the modular construction industry. First, AI, as the owners, did not have sufficient knowledge of the modular construction process to write a bid package that allows for more than one company to bid. Timelines specified in the bids did not fit the modular process, and capacity requirements don’t take into consideration yard space and other storage requirements unique to modular buildings. The costs of transportation were also not adjusted according to the location of the project, resulting in large variability in bid pricing.

The bid package for AI’s School Board projects will be revised, and they are now hoping to examine the bid package for Courts. The collaborative process that brought together owners and builders was very successful, and should be emulated in other projects.

4.0 Round Table Discussions

Workshop attendees were divided into five groups, with an effort to ensure a good mix from academia and industry. Each group was provided with a topic related to challenges within modular and offsite construction. The groups were then asked to brainstorm and identify the causes and effects that may lead to substandard performance under their assigned topic, as well as key research, development, and educational needs that could potentially address the issues.

4.1 Topic: Negative Stigma and Marketing

There is a negative stigma associated with modular and offsite construction, as well as misconceptions that modular construction is of lower quality than traditional on-site, and that it is intended primarily for temporary single-storey buildings. This group was requested to:

Discuss the realities of this stigma and how it affects the adoption of modular construction—for example, does it affect who target audiences are? Do businesses need to take on the challenge of re-orienting customer expectations? In what ways can research contribute to informing the public?

Comments:

There is a significant difference between the expectations of "what a house is supposed to be" and what modular construction is marketed as. The majority of owners don't care about the means and methods by which their building is constructed, just the effectiveness of the process and the end product.

In an effort to increase market demand and awareness there needs to be more advocacy, similar to the adoption of LEED and "green" building technologies, which became a desirable feature for homeowners. There is also a need for more success stories, and for the modular process to be part of the home buying experience, e.g., when homeowners are permitted to tour fabrication factories and assembly yards, etc.

A setback to having a large scale marketing push is that many modular suppliers cater to their local areas only, and investing in partnerships and awareness initiatives outside of that are not seen as very profitable.

4.2 Topic: Lack of Evidence of Past Success

There is a lack of evidence and awareness of successful implementation of modular construction utilizing mixed use of concrete, steel, masonry, and wood for mid-rise and high-rise building projects. This group was requested to:

Discuss how a lack of evidence of past success affects the adoption of modular construction—for example, why is there a lack of readily available evidence, despite the widespread implementation of modular and offsite construction? What roles do industry and academia play in overcoming this difficulty?

Comments:

This issue is related to procurement strategies as well as standards and regulations. Many new building technologies have been proliferated after a publicly sponsored, large-scale project is undertaken; smaller projects often don't have the capability to overcome obstacles such as bidding, dealing with workforce regulations, etc., and much of the effort needs to be done up-front, which is a large cultural shift for the construction industry. It is also better if there are

government sponsored case-study projects as it is difficult for those in the industry to bear the burden of acting as a "guinea pig" for new technologies.

Much of the problem with the "lack of evidence" is not a lack of examples, but a lack of proliferation, which is why large projects make a good first step. Other sectors and countries also have many different places where the public can view innovative technologies such as the innovative case studies of FPInnovations that demonstrates different wood technologies.

There is also a lack of scientific data and research. A great deal more research is needed in modular housing.

4.3 Topic: Standards and Regulations

The existing building code, bylaws, and operational standards are systemically more conducive to conventional construction practices. This group was requested to:

Discuss and provide specific examples of the ways in which legislation and regulations are oriented to favour traditional on-site construction over offsite and modular, and discuss means for overcoming these difficulties. For example: Who are the stakeholders who may be able to adjust standards and regulations? How can both academia and industry work to overcome such challenges?

Comments:

The issue may not necessarily lie with the system, i.e., there are no rules that make it illegal to build modular, but modular and offsite construction is outside the current building tradition within which inspectors, regulators, owners, etc., operate. There are also secondary regulations that affect the modular construction industry. Transportation regulations can greatly affect the cost, design, timing, etc., of a project, especially when companies are operating across several jurisdictions that may have different rules between them. There are also regulatory bodies such as warranties, WCB, etc. All of these affect modular, and most problems arise due to the fact that offsite construction differs from standard procedures, and while not being prohibited, it often does not fit the standards and regulations in the same way as traditional methods.

4.4 Topic: Procurement Strategies

At present, the dominant practice for public procurement is for projects to be awarded to the lowest bidder. A value-based system for procurement may create new opportunities for modular construction, which provides advantages that conventional construction cannot offer. This group was requested to:

Discuss the existing procurement strategies that do not fit offsite and modular construction. Discuss how procurement strategies can be changed to allow for modular and off-site construction bids. For example: What potential difficulties and roadblocks are there with implementing such a strategy? Would new procurement strategies promote joint ventures (e.g., between manufacturers and general contractors)?

Comments:

Issues with procurement lie in the blending of manufacturing and building construction: is a modular built house equipment, or is it property? Agreements between stakeholders need to be very clear on which points in the

construction process indicate a change in ownership. There needs to be a system that allows for progress draws while the building is still in the factory.

Another issue is bidding processes that have specs originated with conventional construction in mind. The strategy used to execute a project should be established up front—because the two modes of building differ so much.

4.5 Topic: Project Financing

Current practice involves progress-based financing of projects, which inherently favours conventional construction. Public project owners recognize that modular builders will invest significant resources on a product upstream prior to onsite assembly (i.e., when the product is still in the factory or in storage, thus creating a cash flow challenge under the current system), and poses the need to restructure project financing and streamline cash flow for publicly-funded projects to enable the use of modular. This group was requested to:

Discuss examples of project financing barring the implementation of modular construction in projects where offsite would have been ideal. Discuss the ways that project financing can be changed to allow offsite construction, and any obstacles to this. For example: Identify stakeholders in the financing process, and how they can be better informed. How can research contribute to restructuring?

Comments:

A key advantage of modular and offsite construction is the predictability of cost and schedule, how can this be sold as reducing risk and establishing new ways of paying people?

Ownership for modular and offsite construction needs to be redefined, i.e., when does the building belong to the client? And how are progress payments made? The design-build method provides a rough framework for a possible solution. Alberta Infrastructure was also examining various possibilities for solving this issue, including having yard storage time limits and bonding schemes.

5.0 Summary and Recommendations:

The workshop served as a platform for members of industry and academia to discuss issues and challenges confronted in an effort to expand and advance the utilisation of Canadian modular construction.

Participants reached a general consensus during the presentations, discussions, and deliberations that an opportunity exists for the modular industry to expand a great deal into the construction market. In order to do so, the following recommendations need to be considered:

First, to collaborate with and support the public sector to act as prominent owners, and drivers behind positive change. It has been historically proven that a substantial market shift, such as the one discussed in this workshop, needs leadership and commitment from public owners, in consultation with contractors, fabricators, material suppliers, and academics (experts). This enables changes in regulations and contractual agreements to take place, promoting innovation, value based procurement systems, and more hybrid construction.

The second major recommendation is for industry leaders and academics to study heavy industry and other applications where modular construction has been employed for some time. The iterative improvements and advances made in these areas can provide direction for the remainder of the modular construction industry.

The third recommendation is for an increase in pilot projects that utilize advanced modular and offsite techniques. Government bodies should initiate such exemplar projects in the education, public health, and social housing sectors, in collaboration with industry leaders and academics, to provide examples and techniques for future modular construction.

6.0 Additional Information

6.1 Keynote Address of the Dean of Engineering, Concordia University, Dr. Amir Asif

Dean Asif received both his Masters and PhD degrees from Carnegie Mellon University, Pittsburgh, Pennsylvania. He previously served as a faculty member at Carnegie Mellon University, Simon Fraser University, and York University, where he was the founding departmental chair of the Department of Electrical Engineering and Computer Science enabling the formation of Lassonde School of Engineering. His research interests are in signal processing with applications in medical devices, radar and sonar applications, and power distribution systems.

Address:

"As the engineering profession continues to evolve, universities and industry in North America and beyond face the challenge of maintaining their role as world class institutions training highly qualified professionals in next-generation technologies and engineering fields such as Modular Construction—the theme of the workshop. University-industry collaboration is vital to develop products that meet society needs. Such industry-sponsored university research is often developed into practical applications that benefit society. Indirectly, university-industry partnerships spawn new industries that enhance the North American competitive advantage globally.

Most infrastructure around the world requires constant maintenance and refurbishment. In the Canadian context, the infrastructure, roads, bridges, and buildings require a major overhaul. The theme of industrialized modular construction is, therefore, very timely as modular construction aims to address the infrastructure challenges. Modular construction is a need of the global society, providing many advantages over conventional construction. Modular construction allows for the buildings and the site work to be completed simultaneously reducing the overall completion time. Assembly itself is independent of weather, increasing work efficiency. While waste from a site-built dwelling may typically fill several large dumpsters, construction of a modular dwelling generates much less waste and is environmental friendly. Modular construction reduces waste and site disturbance compared to site-built structures. I sincerely believe that workshops such as this enables researchers to get together, collaborate with industry, and develop environmental, sustainable, and economical solutions that benefit all.

At Concordia, we pride ourselves on being problem solvers. We have a strongly committed cohort of about 200 professorial faculty members pursuing cutting-edge research and providing outstanding education to over 7,500 undergraduate and graduate students. We have an incredibly balanced undergraduate to graduate student ratio of almost 1:1. The programs offered by Concordia cover all engineering domains, including civil engineering, building engineering, environmental engineering, electrical engineering, computer engineering, mechanical engineering, industrial engineering, software engineering, and aerospace engineering. All of our engineering programs are accredited for the maximum duration by the Canadian Engineering Accreditation Board. Our students are highly sought after and recognized by both industry for their skills and exceptional training, and universities as

prospective graduate students and faculty members. For the last several years, our enrolment has been growing steadily between 15 and 20 per cent annually. We continue to attract top students from all over the world, not only from Canada. And we have wonderful teaching and research facilities, among the best in the country. If you have some time during or after the workshop, I invite you to visit Concordia (only a few blocks from here) and see for yourself some of our teaching and research facilities. It is an honour for Concordia to be part of this wonderful workshop. Whether we belong to academia, industry, public or private sector, our research and design activities push boundaries because we look to our communities for inspiration. That is what you will all be doing here today. Reaching as a community you will all be looking at what is working and what needs to be improved in modular construction. The challenges you face are not small: infrastructure aging problem in Canada is something we are all very familiar with irrespective of the part of the country we belong to. The extreme Canadian climate poses another challenge and our infrastructure should be immune to extreme swings in weather conditions. Geographically distant and isolated regions pose another challenge. The size of our country and our lean population density means that we are spread out. We need to transport materials over great distances and to remote locations on a regular basis. In recent years, most institutions in Canada have faced considerable fiscal challenges, which means that we must stay lean as an institute and yet continue to contribute in the development of next generation engineering technologies and structures. Despite these challenges, I have full confidence in the abilities of engineers, especially Canadian engineers, to continue to lead and contribute towards developing solutions for the societal needs in the coming years and decades.

It is with this promise that I wish you a very successful workshop and look forward to learning more about modular industrialized construction by virtue of the findings of this workshop through its proceedings."

6.2 Further Reading

Ryan E. Smith and the Modular Building Institute Foundations (2015). *Permanent Modular Construction: Process, Practice, Performance.* Available at:
http://www.modular.org/HtmlPage.aspx?name=foundation_offsite_PMC_report

- This paper discusses several international projects that utilize permanent modular construction (PMC), as case studies to examine the processes involved, and outcomes, and compare the off-site processes to traditional construction methods.

Other Modular Building Institute Resources, available at:
www.modular.org

APPENDIX A

LIST OF ATTENDEES

Invitee Name	Affiliation
Academic Participants	
Ying-Hei Chui	University of New Brunswick
Zhenhua Zhu	Concordia University
Lloyd Waugh	University of New Brunswick
Jeff Rankin	University of New Brunswick
Yuxiang Chen	University of Alberta
Neil Eldin	University of Houston
Raymond Issa	University of Florida
Amin Hammad	Concordia University
Farnaz Sadeghpour	University of Calgary
Simaan AbouRizk	University of Alberta
Tarek Zayed	Concordia University
Talal Amhadi	Concordia University
Mojtaba Valinejadshoubi	Concordia University
Jeff West	University of Waterloo
Carlo Carbone	Université du Québec à Montréal
Ashutosh Bagchi	Concordia University
Avi Friedman	McGill University
Hossein Abaien	Concordia University
Tarek Salama	Concordia University
Industry Participants	
Martin Tite	GRC Architects
Tony Begin	Canam Group INc
Pierre Boucher	Canadian Construction Innovations
Laurie Robert	NRB Inc
Rick Weste	Triple M Housing Ltd
Jacques Roy	Maple Leaf Homes Inc
Kathleen Maynard	Canadian Manufactured Housing Institute
Peter Lister	FPInnovations
John Bockstael	Bockstael Construction Ltd
Gilles Bernardin	Defence Construction Canada
Christian Daniel Asiminoaie	CANAM Buildings
Marc Lapointe	Société d\'habitation du Québec
Chantale Germain	Hydro-Québec
Paul Verhesen	Clark Builders
Ray Girouard	Kent Homes
Steven Williams	MBI

Pierre Lapointe	FPInnovations
David Saucy	Kent Homes
Pierre Larouche	Lemay
Bill Haliburton	ATCO Structures & Logistics
Brian Keyes	GLP Canada
Dino Zuppa	NSERC
Tim Smith	Ellis Don
Michelle Patchett	Ellis Don
George Charitou	Ellis Don
Sandra Nigro	MHA
Dupuis Roger	Kent Homes
Shawn Gardner	Public Works Canada
Les McMullan	HATCH
Randy McGee	Defence Construction Canada
Subhi Alsayed	Tridel Homes
Pierre Collot	ETS-GRIDD
Stephen Coote	CCI / Group 92 Mechanical Inc
Julian Bowron	VectorBloc
Nagima Essop	PCL
Guy Huot	Hydro-Québec
George Poumbouras	Canam
Parisa Allahyari	Hydro-Québec

Workshop on Industrialized Construction:

Challenges and Opportunities for Modular Construction in Canada

October 29th - 30th, 2015

Le Centre Sheraton Montreal Hotel
1201 Boulevard Rene-Levesque West, Montreal

Hosted by:

UNIVERSITÉ Concordia UNIVERSITY

MODULAR BUILDING INSTITUTE

Partner:

NSERC CRSNG

The adoption of the industrialized construction method in Canada is limited due to several issues: 1) Negative stigma, 2) Shortage of examples of past success, 3) Standards and regulations, 4) Procurement strategies which favour conventional construction technologies, and 5)Project financing.
The purpose of this workshop is to connect academia and industry to potential solutions to these limitations, serving as a platform for networking opportunities for all those involved, and starting point for innovations.

With your input, we expect a productive and engaging event!

Program:

Thursday, October 29th

17:00 *Dinner-Reception (Jarry-Joyce)*

Keynote Address:
Dr. Al-Hussein, NSERC Industrial Research Chair (IRC) in the Industrialization of Building Construction
-The IRC addresses fundamental questions of how to reach building construction industrialization, and has produced significant results in the areas of: Improved factory performance through the use of simulation tools; Integrated computer tool innovations for design and drafting of the modular construction manufacturing process; Integrated BIM modelling for the purpose of occupational health hazard assessment and the modification of construction scheduling; Automated optimization of heavy lift crane configurations; and many others in collaboration with industry and government partners.

Friday, October 30th

7:00 *Breakfast & Overview (Jarry-Joyce)*

Introductions and Overview
Dr. Osama Moselhi, Department of Building, Civil, & Environmental Engineering
Dr. Amir Asif, Dean of Engineering, Concordia University

8:00 *Phase 1 Panel: Industry*

Industry Panel Members:
Industry experts will speak on modular construction in Canada, and specifically within their fields of expertise, discussing barriers to advancement and potential opportunities. Following this will be an open discussion.

10:00 *Coffee Break (Jarry-Joyce)*

10:30 *Phase 2 Panel: Academia*

Academic experts will speak on modular construction in Canada, and specifically within their fields of expertise, discussing barriers to advancement and potential opportunities. Following this will be an open discussion.

12:30 *Lunch (Club Lounge)*

Keynote Address:
Steven Williams, President of the Modular Building Institute (MBI). The MBI and it's two educational foundations promote the use of offsite and modular construction practices through outreach and education, and by connecting researchers and educators with manufacturers, contractors, and dealers in the industry.

13:30 *Round Table Talks (Jarry-Joyce)*

Tables are presented a discussion question/topic by the hosts. Topics are selected from previous analysis of target areas for improvement of modular construction in Canada.
Each group will brainstorm and identify the causes and effects that may lead to substandard performance under their assigned topic, as well as key research, development, and educational needs that can potentially address the identified causes.

14:30 *Summary of Discussions*

Groups present their discussion outcomes.

15:15 *Closing Remarks*

Following the Workshop a document summarizing the discussions and presentations will be created and distributed to attendees.

Thank you for registering!

Additional Sponsorship provided by:

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Canadian Construction Innovations

UNIVERSITY OF ALBERTA

MODULAR AND OFF-SITE CONSTRUCTION SUMMIT