2018 Modular and Offsite Construction (MOC) Summit
@
World of Modular, March 22-25
The Diplomat Beach Resort, Hollywood, FL, USA

Modular Industry Characteristics and Barriers to its Increased Market Share

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ABSTRACT

Modular and offsite construction reduces project duration and cost by synchronizing offsite and onsite work. Project activities are constructed in a controlled offsite facility to minimize effects of inclement weather and site disruptions, while meeting safety and quality requirements. In recent years, many organizations have conducted questionnaires to study characteristics of modular and offsite construction, such as the Modular Building Institute (MBI), Buildoffsite campaigning organisation in the UK, Canadian Manufactured Housing Institute (CMHI), National Institute of Building Sciences, McGraw-Hill Construction, and Fails Management Institute (FMI). This paper introduces a summary of results for a new questionnaire carried out in collaboration between the Department of Building, Civil and Environmental Engineering (BCEE) at Concordia University, MBI, Niagara Relocatable Buildings, Inc. (NRB) in Canada, and the Nasseri School of Building Science and Engineering at the University of Alberta. This questionnaire focuses on two issues: (1) the characteristics of the modular and offsite construction industry, and (2) detected barriers to the increased market share of this industry. For the latter, effort was made to address five factors emanated from a workshop on "Challenges and opportunities for modular construction in Canada" held in Montreal in October 2015 to analyze barriers to growth of modular construction in Canada. Key findings of this questionnaire include requests for use of a separate code of modular construction design, innovative financing and insurance solutions, standards that consider procurement regulations, and lending institutions that partner with financial houses to create special lending programs for modular construction.

KEYWORDS

Project delivery; Questionnaire; Survey; Barriers; Industry characteristics; Modular construction.

INTRODUCTION

This questionnaire extends previous studies that investigate characteristics of modular and offsite constriction. Buildoffsite campaigning organisation promoted offsite construction in UK by

publishing results of industry survey for offsite construction (Buildoffsite, 2006) to measure contribution of offsite industry to gross domestic product of UK and to understand the depth of its supply base. McGraw-Hill construction partnered with modular building institute (MBI) and National institute of building sciences (NIBS) among other collaborators to publish survey results of prefabrication and modularization (McGraw-Hill, 2011). This report investigated impact of prefabrication and modularization on productivity metrics such as project cost, schedule, quality, safety, utilizing building information modelling (BIM), creating green buildings, and eliminating waste. Fails management institute (FMI) corp. introduced survey results (2013) for prefabrication and modularization which investigated labour savings, market growth, return on investment (ROI), strategic marketing approach, benefits of prefabrication, annual sales, and factors driving prefabrication demand. Report presented by NIBS (2014) focused on annual revenues, project types, stakeholder collaboration, benefits of off-site construction, and barriers of implementing off-site construction. Smith and Rice (2015a, 2015b) collaborated with MBI and NIBS to study offsite processes of modular construction by analysing case studies. These studies identify performance metric parameters for schedule, cost, risk, quality, safety, and scope. As well as comparing modular to traditional construction to investigate added value, benefits, and barriers of implementing modular construction. Canadian manufactured housing institute (CMHI) conducted a survey for producers of factory-built homes (2016) to study value of manufactured buildings in Canada, volume of international trade for manufactured buildings, annual construction investment by sector, generated jobs by manufactured building industry, economic activity and impact, wages and business profits, and federal and provincial taxes for manufactured buildings. MBI introduces analysis of modular industry in regular basis through its annual reports for permanent modular construction (PMC) and modular advantage publications (MBI-PMC, 2015; Modular advantage, 2017). MBI collects data internally through its members while renewing annual memberships. MBI data represents about 75% of industry assets and revenue of relocatable buildings industry in North America (Modular advantage, 2017). MBI reports focus on studying market share, growth forecasts, size of market, and production benchmarks. MBI goal is to focus efforts and resources to increase market share of modular building industry from current estimates of 2.5% to 5% by 2020 using 5-in-5 industry growth initiative introduced in 2015. Smith and Quale (2017) conducted comparative analysis between reports of McGraw-Hill construction, NIBS, and FMI corp. and provided quantitative and qualitative analyses for Smith and Rice work (2015a, 2015b). However, these studies did not investigate some of current practices for modular construction such as type of project delivery system, type of contracts, type of procurement method, synchronization of onsite and offsite schedules, BIM applications and software, scheduling software, and barriers to increased market share. Thus, this paper presents summary of findings for current practices in modular construction and investigation for barriers to increase market share by focusing on five hypothesis points which are negative stigma, shortage of examples of past success, standards and regulations, procurement strategies, and project financing.

QUESTIONNAIRE METHOD

Questionnaire was available online using Google forms starting from 16th of April till 4th of August 2017, and 58 responses were received from 11 countries including Canada, USA, UK, China, Australia, New Zealand, Brazil, Russia, Slovenia, Saudi Arabia, and UAE. Questionnaire was sent to nearly 1000 modular construction professionals using LinkedIn messaging and emails.

First part (Industry characteristics)

The study captured current practices in modular construction such as: 1) type of material used, 2) type of produced modules, 3) type of modular construction project, 4) responsibility for activities of modular construction projects, 5) scheduling software used, 6) synchronization of onsite and offsite schedules, 7) collecting productivity rates for onsite and offsite construction, 8) type of project delivery system, 9) type of procurement method, 10) type of contracts, 11) square footage for modular projects, 12) difficulties in modular projects, 13) distance between manufacturing facility and project construction site, 14) average transportation cost, 15) crane type, 16) daily placing rate, 17) average lifting capacity for crane, 18) BIM applications and software. Modular construction proved to be the most promising category of offsite construction. Percentage of respondents was 77.8, 48.1, 37, 35.2, and 24.1 % for constructing modular, prefabricated components, panelized, bathroom pods respectively. Steel is dominant material type with 79.6% of respondents comparing to 63 and 27.8 % for wood and concrete respectively. While respondents reported emerging materials utilized such as polyurethane foamed panels, glass reinforced polymers (GRP), and aluminum with 3.8, 1.9, and 1.9 % respectively. Nearly half of responses indicated that daily placing rate for modules onsite (lifted modules per day) range between 5 to 10 as shown in Figure 1 and that hydraulic truck crane is utilized for this mission. Majority of modular and offsite projects utilize design build (DB) as project delivery system as shown in Figure 2. This result matches Smith (2010) conclusions that DB facilitates early decision making which is required by modular construction to improve constructability and coordination. Design bid build (DBB) contracts declined steadily in use, while integrated project delivery system is emerging (Smith, 2010). Logical results were drawn from comparing investigated characteristics based on percentage of responses for DB, DBB, and IPD, while low number of responses for construction management at risk (CMAR) did not allow for comparing its results. For example, percentage of responses for utilizing bidding strategy of “best value” which combines two envelopes procedure plus negotiations is the highest in IPD as shown in Figure 3. It is descending in DB, DBB, and CMAR in logical manner, while no lower bidder procedure is utilized with IPD and no personal bidding with DBB. Same logic is found in percentage of respondents utilizing MS project for scheduling. It is 65, 57, and 46 % for IPD, DB, and DBB respectively because MS project increase interoperability among project stakeholders by its popularity which is mostly needed in IPD. Importance of adequate scheduling is investigated by studying synchronization of offsite and onsite schedules and for collecting productivity rates of offsite and onsite operations. Percentage of responses for schedules synchronization is 87, 82, and 72% and 73, 61, and 28 % for collecting productivity rates of IPD, DB, and DBB contracts respectively.

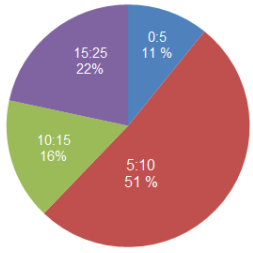

Figure 1. Daily placing rate for modules.

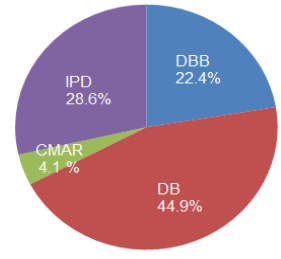

Figure 2. Project Delivery Systems.

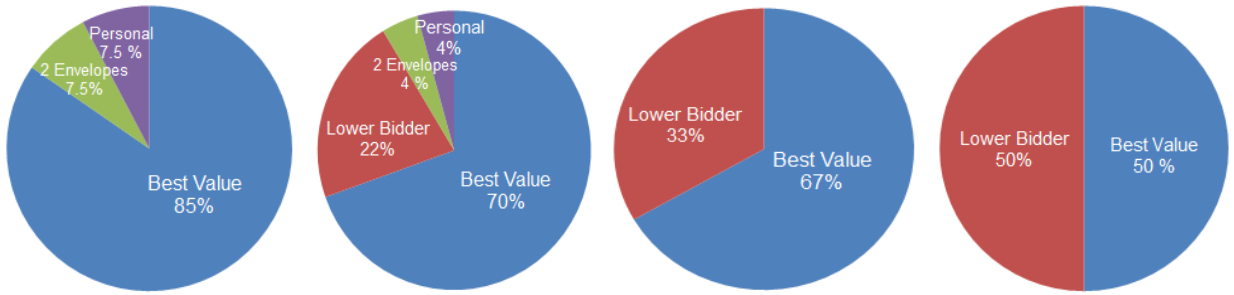

Figure 3. Bidding Strategy.

This indicates that IPD contracts have the best scheduling features that fit short schedules of modular construction. Percentage of responses for BIM utilization follow same trend of increase with IPD. It is 57, 48 and 50 % for IPD, DB, and DBB respectively, due to the need for better collaboration among project stakeholders for IPD contracts. Using popular BIM software facilitates this collaboration. Revit is commonly utilized for modular construction with percentage of responses of 64, 61, and 56 % for IPD, DB, and DBB respectively. Nearly half of responses clarified that computer numeric control (CNC) of manufacturing processes and virtual reality (VR) goggles are considered as future applications of their operations. While 42, 42, and 28 % of responses considers radio-frequency identification (RFIDs), 3D printing, and 3D point cloud technologies. Obstacles and difficulties faced by modular builders are ranked based on percentage of respondents as follows: 1) contractors experience is not enough in applying modularization concepts (61.5%) , 2) design scope was not be frozen early in project schedule (50%) , 3) onsite and offsite schedules were not synchronized (34.6%) , 4) module envelope limitation (dimensions limitation) restricted architectural design (32.7%), 5) scheduling method utilized was not suitable for project (7.7%), 6) selected project delivery system was not suitable for project (5.8%), 7) attitudes of public inspectors (1.9%). Commonly experienced distance between manufacturing facility and construction site is shown in Figure 4 by two limits (minimum and maximum) as well as its relative average costs per module square footage.

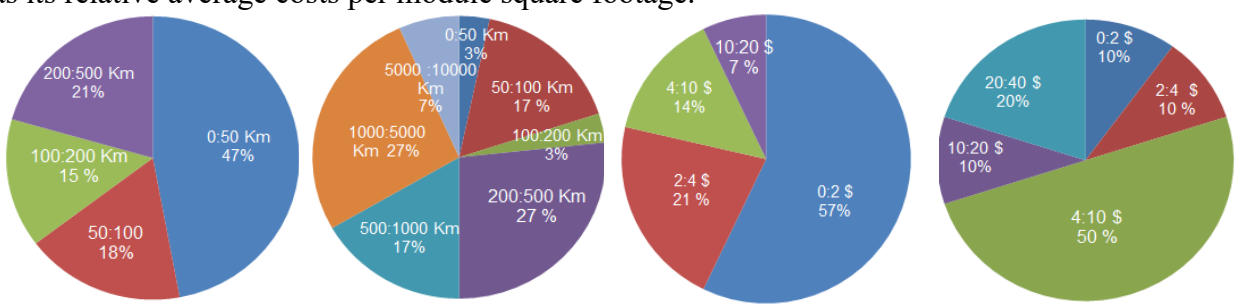

Figure 4. Transportation distance and cost.

Second part (Barriers to increased market share)

First hypothesis (negative stigma)

More than half of responses agreed that there is negative stigma associated with modular construction as shown in Figure 5. This is attributed to misconception that modular is intended primarily for temporary, single-storey applications. Percentage of responses which agreed that significant advantages of modular construction are not communicated properly with owners is

70%. While 80 % of responses agreed that there is shortage of well-designed marketing campaigns conducted by modular institutions and manufactures, and 90% agreed that owners are not familiar with different products offered by modular industry. Most responses agreed also that there is lack of academic research which highlights advantages of modular construction as shown in Figure 6. Respondents suggested conducting international cooperation for all parties of modular construction industry to show American and Canadian ideas to European industry and vice versa. As well as establishing advertisement campaign in North America for modular construction that communicate pros and cons of modular construction in terms of quality, environment, flexibility in design, and return of investment (ROI). Engaging industry and academic partners is also suggested for strategic planning of research and development of modular construction as well as offering university and training courses.

Second hypothesis (Shortage of examples of past success)
Most respondents agreed that there is lack of promotional materials that depict successes and advantages of modular construction as shown in Figure 7. They also agreed that there is lack of worldwide documentation for lessons learned and lack of owner's knowledge about compatibility of modular construction with different structure types and materials. As well as lack of government-sponsored case studies that highlight obstacles and opportunities for modular construction and lack of available data to support decision making as shown in Figure 8. Respondents recommended for MBI, PreFab Australia, and PreFab New Zealand to produce more publications for advantages of modular construction, outreach for owners to convince them of advantages, educate architects, use social media for marketing, and prepare online courses for modular construction. They also recommended institutes and universities to publish more papers, highlight modular advantages in academic courses, and promote modular advantages for authorities. In fact, MBI and Clemson University announced new online course for modular construction in May 2017 after developing textbook for this course named "Introduction to commercial modular construction" (2015). PreFab Australia publishes bi-monthly magazine named "Built Offsite" to highlight offsite construction case studies, developments, and advantages in Australia and New Zealand (2017).

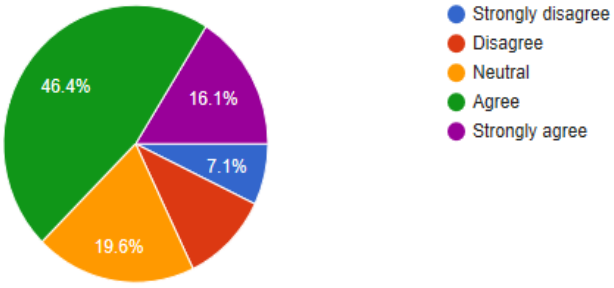

Figure 5. Negative stigma with modular and offsite construction.

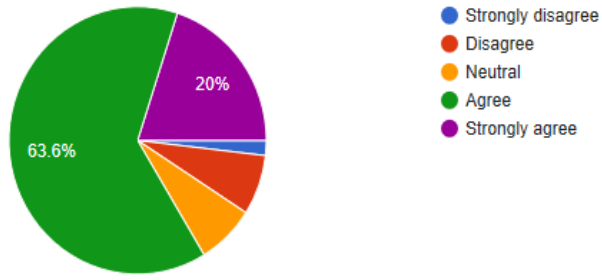

Figure 6. Lack of academic research for modular construction.

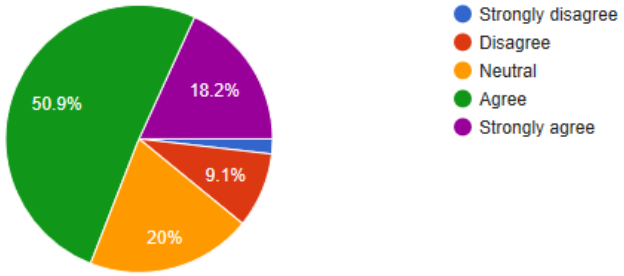

Figure 7. Lack of promotional materials for successes and advantages.

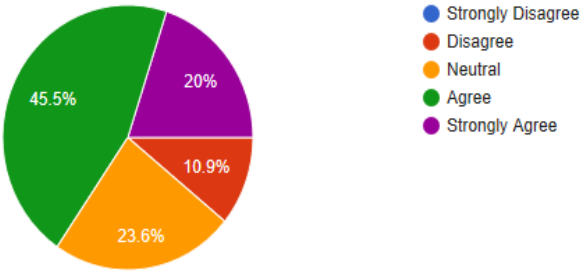

Figure 8. Lack of available data to support decision making.

Third hypothesis (standards and regulations)

Most respondents disagreed that existing regulations are not obstacles for modular industry as shown in Figure 9. Percentage of responses is 83.6 % who agreed that transportation regulations affect cost, time, and design of modular construction as shown in Figure 10. Respondents recommended for MBI, PreFab Australia, PreFab New Zealand to support use of separate design code for modular construction and to contact governments at all levels to lobby for modular friendly regulations as well as educating inspection community of modular construction. They also recommended institutes and universities to develop research that ties codes and standards with theoretical background of modular construction while finding gaps between modular construction and current standards. As well as introducing modular concepts to architectural departments. In fact, PreFab Australia partnered with Monash University, modular construction codes board (MCCB), Government of Victoria, Engineers Australia, and Australian Steel Institute to develop handbook for design of modular structures (2017). In June 2017, (MBI) and International Code Council (ICC) developed series of modular-themed guidelines and resources to help code officials become better informed of off-site construction process. Canadian manufactured housing institute (CMHI) and MHICanada created the modular construction council of the Canadian home builders' association (CHBA) to monitor and participate in developing codes, standards and regulations, liaising with codes governmental officials, regulatory bodies, related organizations and the public as well as facilitating research to identify technical problems and supporting development of codes and standards. First meeting of modular construction council was in May 2017 in St. John's, Newfoundland and Labrador.

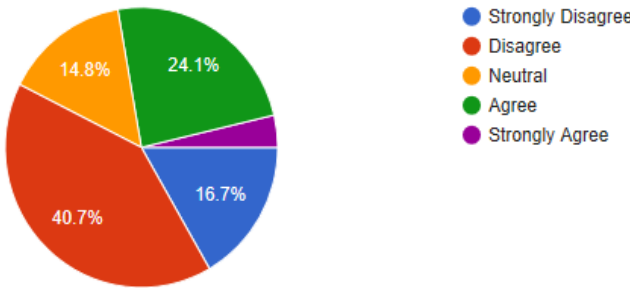

Figure 9. Existing regulations are not obstacles for modular industry.

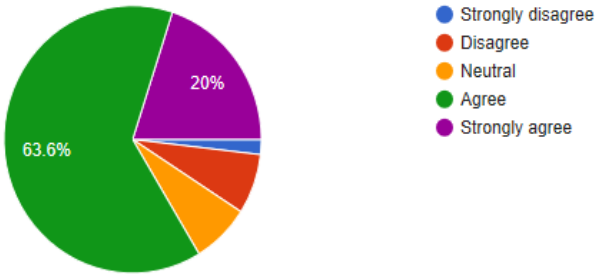

Figure 10. Transportation regulations affect cost, time, and design.

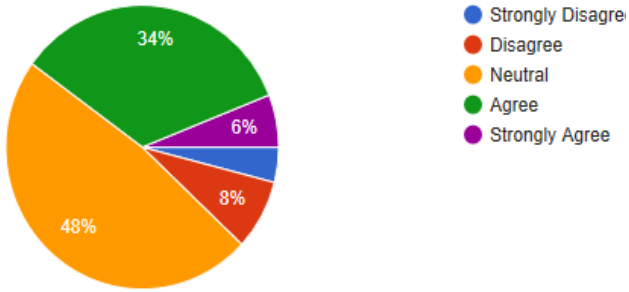

Figure 11. Modular construction imposes changes in perception of ownership.

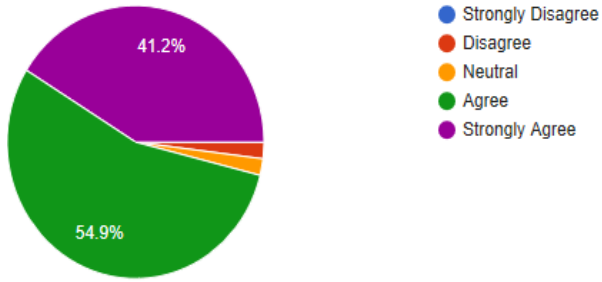

Figure 12. Project execution plan has to be incorporated in bidding process.

Fourth hypothesis (procurement strategies)

Most respondents agreed that modular construction imposes changes in perception of ownership comparing to traditional construction as shown in Figure 11. They also agreed that project execution plan has to be communicated up front and incorporated in bidding process as shown in Figure 12 due to different nature of modular industry that freezes design in early stages of project while having short schedules. Respondents recommended for MBI, PreFab Australia, and PreFab New Zealand to develop codes and standards that consider procurement regulations for modular construction while increasing credibility of suppliers. It is also suggested to study procurement strategies of solar/renewable energy industries as examples of applying innovative procurement, financing and insurance solutions. They also recommended institutes and universities to develop new procurement methods that account for characteristics of modular construction. As well as conducting more research and publications to demonstrate value of automated production, quality control, strength of modular construction versus stick built.

Fifth hypothesis (project financing)

Most respondents agreed that predictability of cost and schedule gives modular industry advantage over conventional construction as shown in Figure 13, and that lower level of risk associated with modular construction encourage stakeholders to adopt new payment methods as shown in Figure 14. Respondents recommended for MBI, PreFab Australia, and PreFab New Zealand to cooperate with financial houses to create financial models that consider characteristics of modular construction as well as creating special conferences for lenders. They also suggested creating special lending institutions while getting banks to change lending policies for modular builders and to convince insurance companies to insure modular buildings at lower rate. They also recommended institutes and universities to design lending programs and cost management methods that account for characteristics of modular construction.

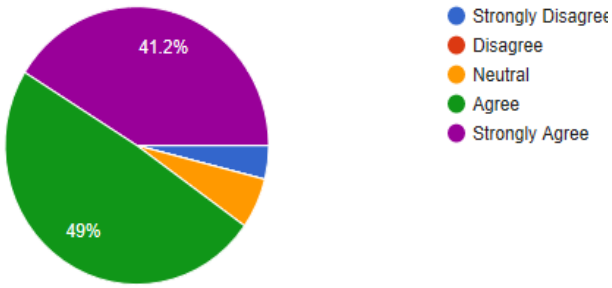

Figure 13. Predictability of cost and schedule gives modular industry an advantage.

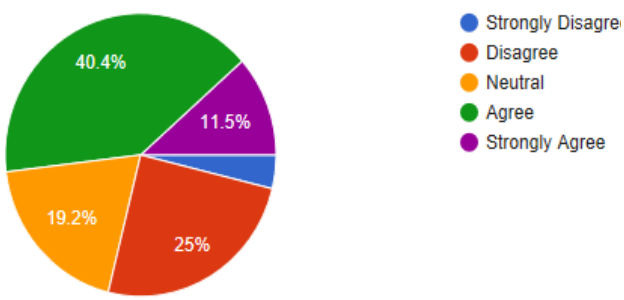

Figure 14. New payment methods for modular construction due to lower risks.

CONCLUSION

This paper presents summary of findings for questionnaire conducted to study characteristics of modular and offsite construction, and to analyze barriers to its growth in 11 countries. Key findings show that DB is the common project delivery system for modular construction, while IPD is emerging and DBB is declining. Nearly half of responses utilize BIM in their operations while Revit is the common BIM software. More than half of responses agreed that there is negative stigma associated with modular construction, and suggested to utilize social networks and online courses to promote modular construction. Respondents support use of separate code of modular construction design and innovative financing and insurance solutions. Full questionnaire findings shall be published shortly as separate report in cooperation with MBI.

ACKNOWLEDGEMENTS

The authors wish to thank Natural Sciences and Engineering Research Council of Canada (NSERC) and NRB Inc. for jointly funding and supporting this study by NSERC Engage Grant for partnerships between academia and industry. They also wish to thank management teams of NRB Inc. namely Mrs. Laurie Robert (Vice President of Sales and Marketing) for her valuable input in the conducted survey, MBI namely Mr. Steven Williams (Operations Director), and Mr.Tom Hardiman (Executive Director) for their support and cooperation in conducted survey.

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