

Modular Industry Characteristics and Barrier to its Increased Market Share

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1- Introduction:

A questionnaire is carried out in collaboration between the department of Building, Civil & Environmental Engineering (BCEE) at Concordia University, NRB Inc. in Canada, the Modular Building Institute (MBI), and the School of Building Science and Engineering at the University of Alberta in Canada. This questionnaire is divided into two parts. The first part addresses the characteristics of modular construction, while the second focuses on five issues emanated from the workshop on “challenges and opportunities for modular construction in Canada” held in Montreal on October 2015 to analyze barriers to growth of modular construction in Canada.

This subject is investigated using a questionnaire which was available online for modular construction professionals starting from the 16th of April till 4th of August 2017, and 58 responses were received from Canada, USA, UK, China, Australia, New Zealand, Brazil, Russia, Slovenia, Saudi Arabia, and UAE after sending this questionnaire to nearly 1000 professionals.

The parameters studied were as follows:

A- First part (Industry characteristics):

The study captured the 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.

B- Second part (Barriers to increased market share):

This part investigated barriers to increase modular construction share by focusing on five hypothesis points as follows:

1) The negative stigma associated with modular and offsite construction which resulted from the following shortcomings; a) shortage of well-designed marketing campaigns for modular construction, b) communicating advantages of modular construction, c) lack of large scale partnership in modular construction, d) lack of academic research for modular construction, e) lack of public awareness of modular construction, f) lack of documentation.

2) There is a lack of evidence of successful implementation of modular technologies utilizing mixed use of concrete, steel, masonry, and wood for mid-rise and high-rise applications. This issue is investigated through the following points; a) lack of promotional materials, b) lack of knowledge about the compatibility of modular construction with different structure types and materials, c) lack of worldwide documentation for lessons learned, d) lack of nationwide documentation for lessons

learned, e) lack of government-sponsored case studies, f) lack of academic research, g) lack of available data for manufacturers and owners to support decision making.

3) The existing building code, bylaws, and operational standards are systemically more conducive to conventional construction practices. This issue is investigated through the following points; a) lack of governmental support, b) transportation constraints, c) The culture of inspectors, regulators, operators, effect on manufacturers, d) The changes of regulations among the different jurisdictions.

4) A value-based system for procurement is needed for modular companies to create new opportunities which offer advantages that conventional construction cannot offer. This point is investigated through the following points; a) the perception of ownership for module, b) incorporating project execution plan in the bidding process, c) The needed actions to overcome the issues associated with procurement for modular construction.

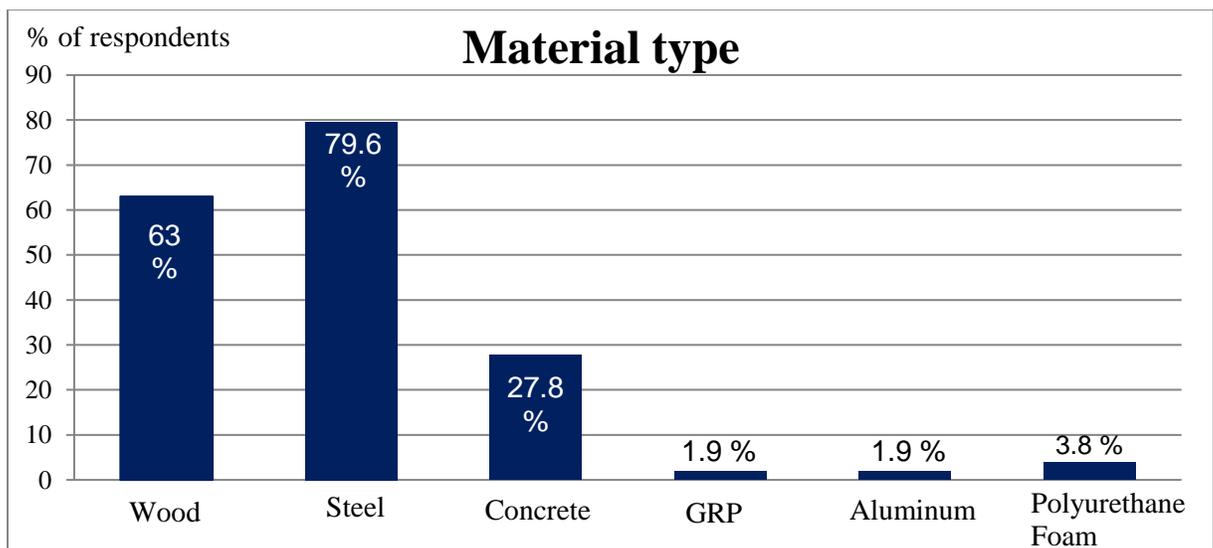
5) The need for innovative financing tools such as employing bonds or warranties to streamline cash flow for publicly funded projects to enable the use of modular. This point is investigated through the following points; a) The advantage of modular industry over the conventional construction due to the predictability of cost and schedule, b) Adopting new payment methods for modular construction due to its lower level of risk comparing to conventional construction, c) storage cost for modules before and after fabrication, d) compliance of modules with its design specification and the associated extra cost to fix this problem, e) The percentage of full contract price for progress levels to determine progress payments to manufacturers.

2- Summary of results:

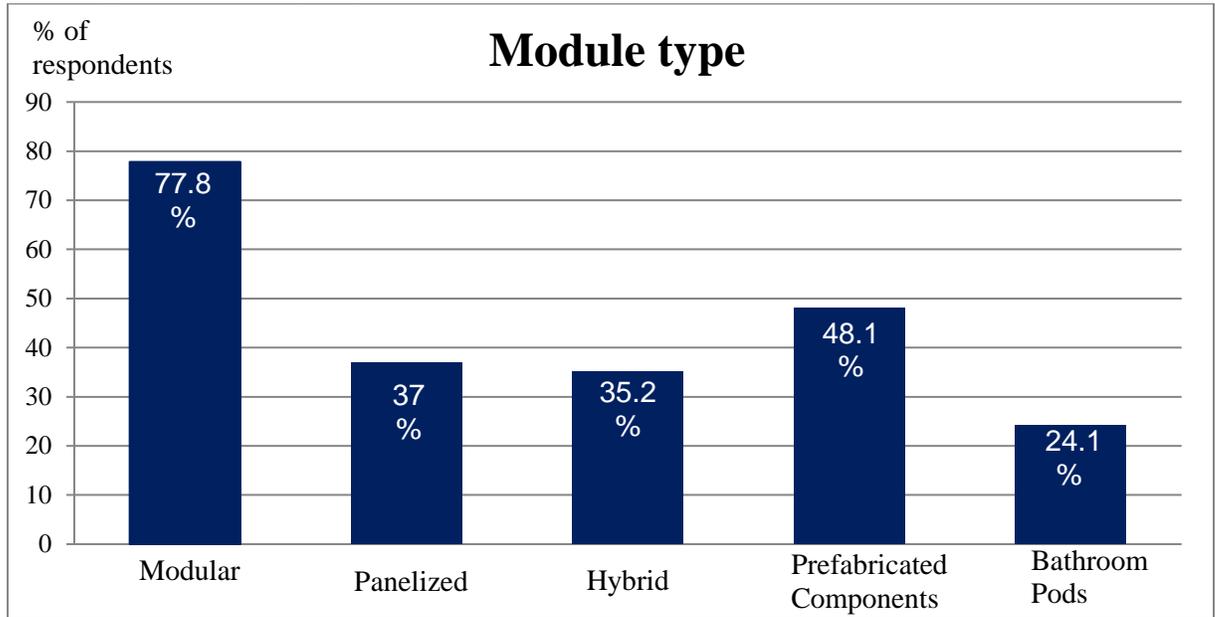
The questions and responses of the questionnaire are as follows:

A- First part (Industry characteristics):

1- What type of material used in fabrication and production of modules?

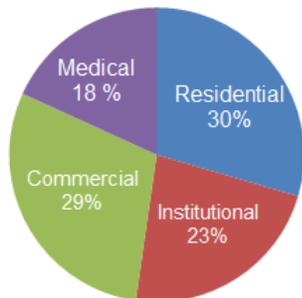


2- What type of modules you produce?

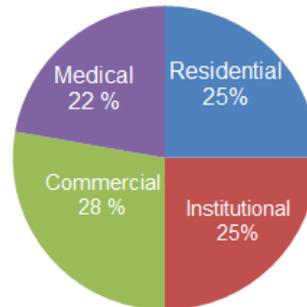


3- What type of modular construction project?

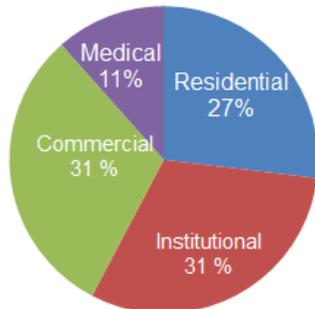
IPD & Project type



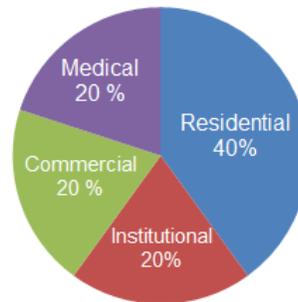
DB & Project type



DBB & Project type

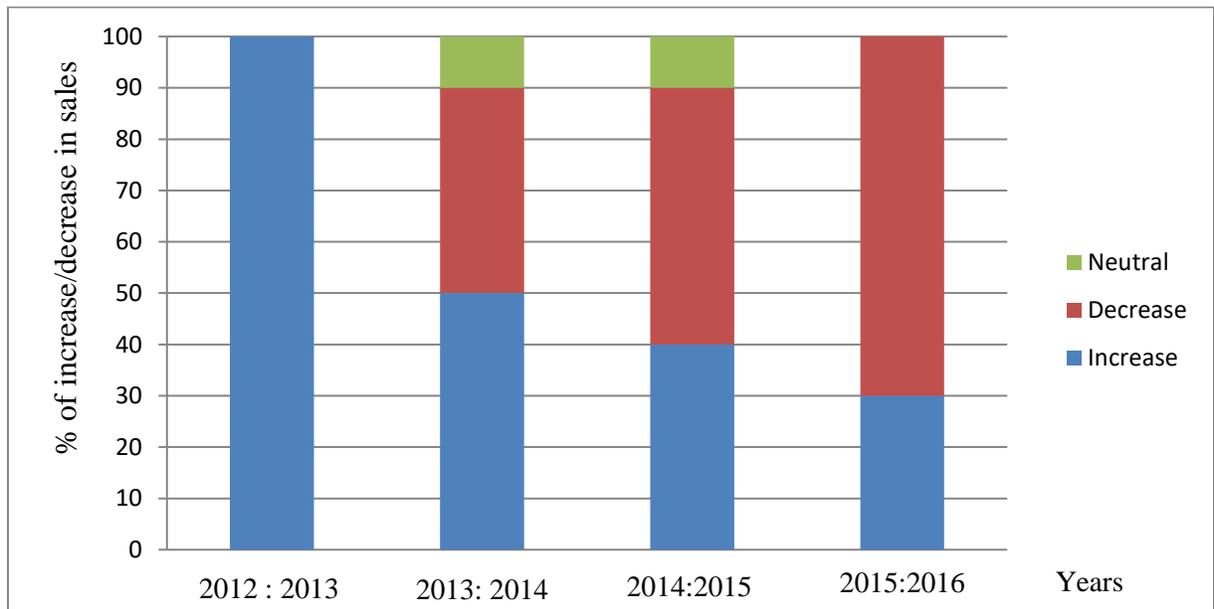
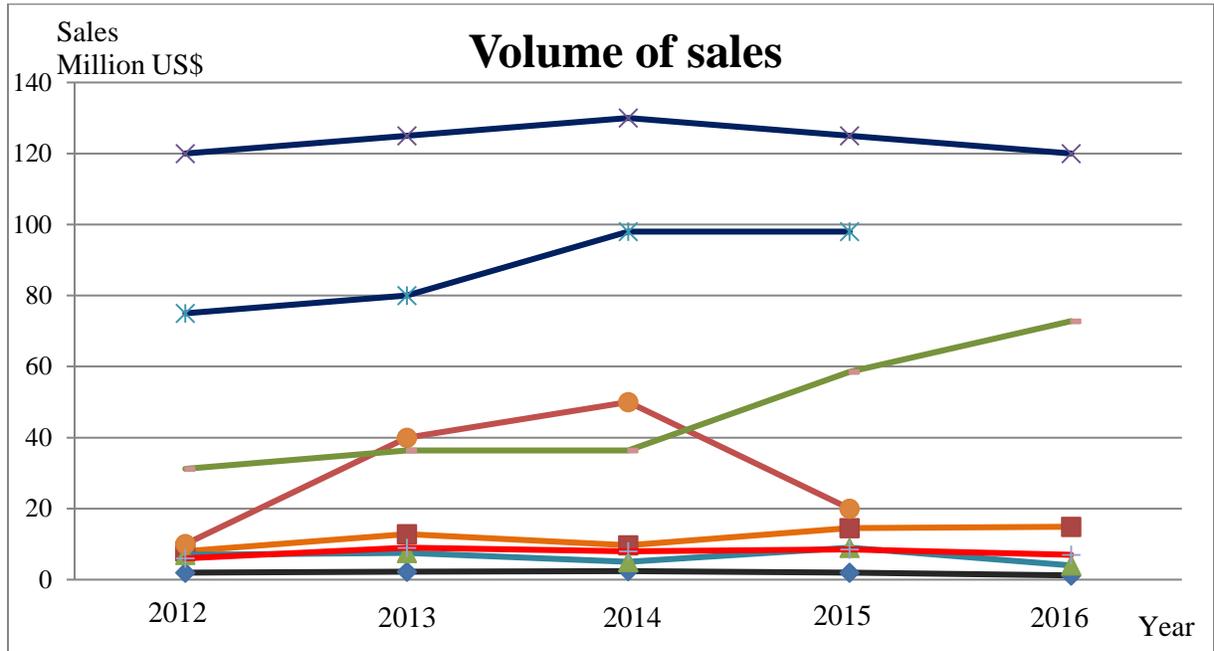


CMAR & Project type



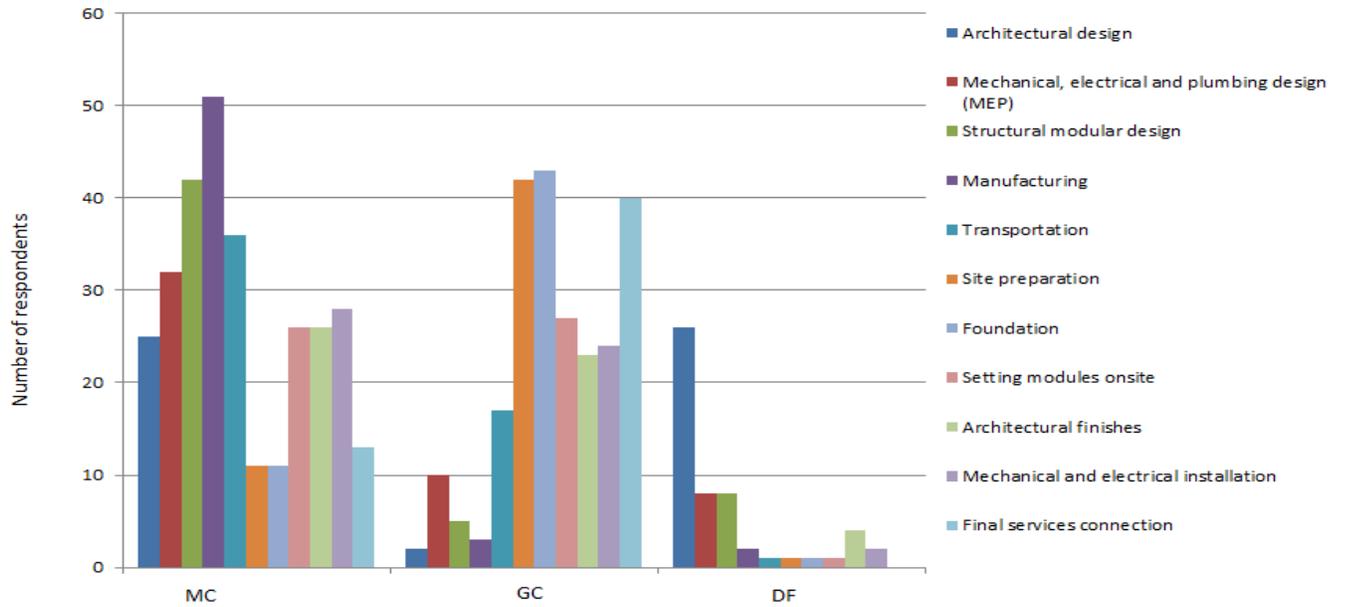
4- What is the volume of sales (dollar value of business) for modular construction of your company over last 5 years (Please write the value of each year separately from 2012 to 2016)?

It is clear that the percentage of responses that incur an increase in sales is descending from 2012 to 2016.



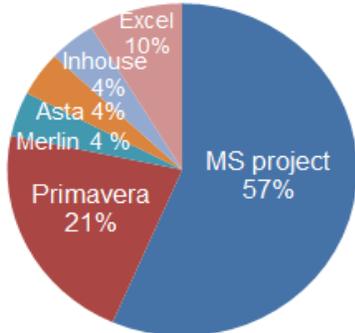
5- Which party is responsible for the following activities in your modular projects?

(MC: Modular Company (manufacturer), GC: General contractor (onsite), DF: Design firm.)

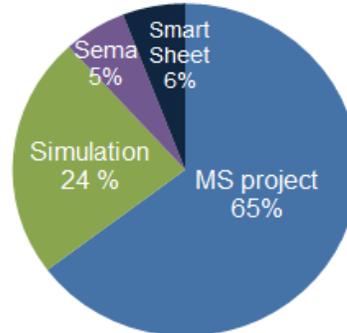


6 - What is the scheduling software/method used in your company?

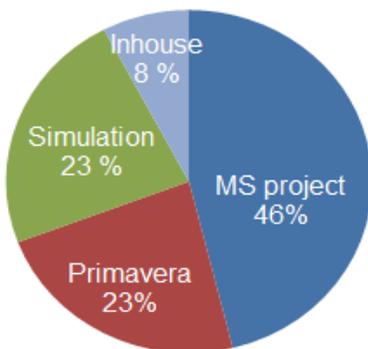
DB & Scheduling software



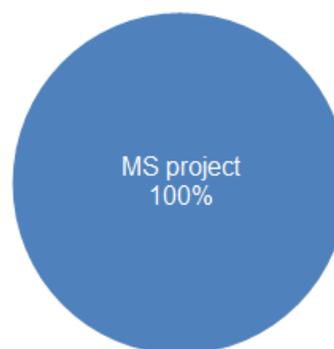
IPD & Scheduling software



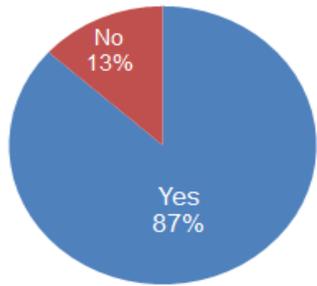
DBB & Scheduling software



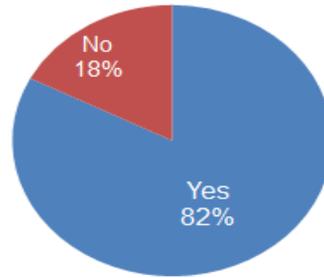
CMAR & Scheduling software



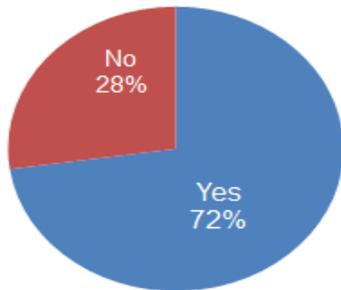
7- Are the onsite and offsite schedules synchronized in your projects?



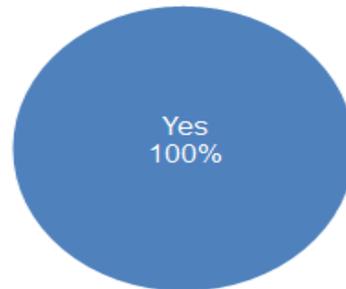
IPD & Schedules synchronization



DB & Schedules synchronization

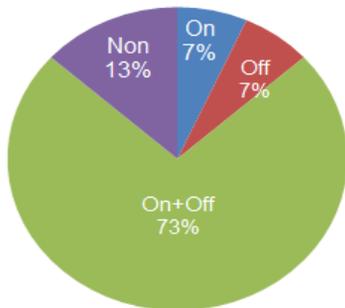


DBB & Schedules synchronization

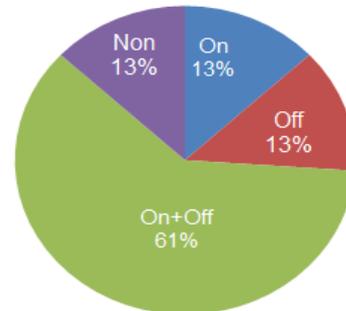


CMAR & Schedules synchronization

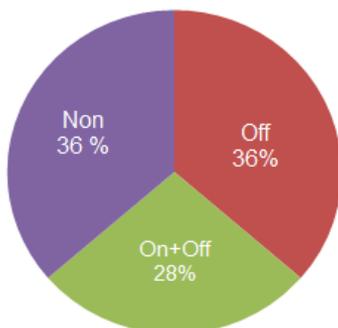
8- Is there any time study conducted to calculate productivity rates for your offsite and onsite operations?



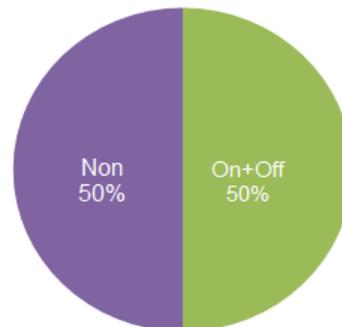
IPD & Collecting productivity rates



DB & Collecting productivity rates

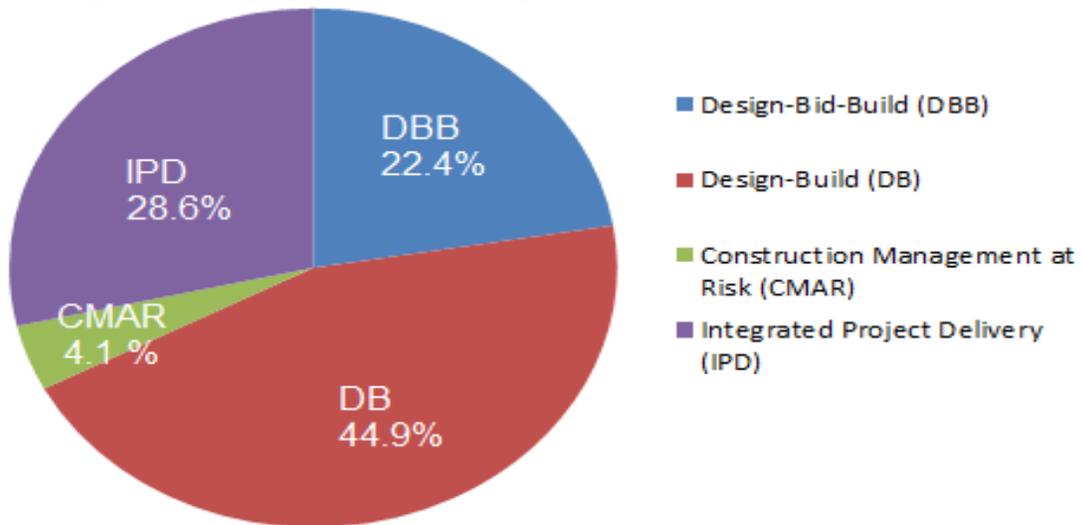


DBB & Collecting productivity rates

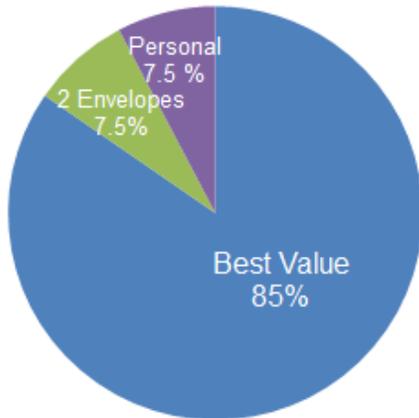


CMAR & Collecting productivity rates

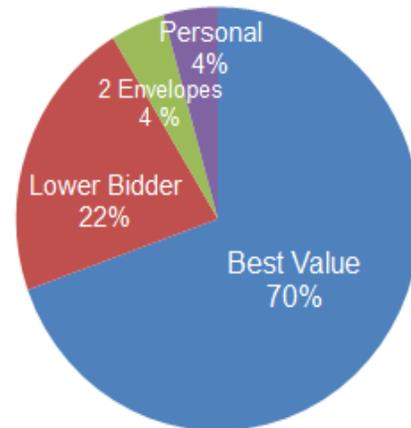
9- Which Project Delivery System is commonly used?



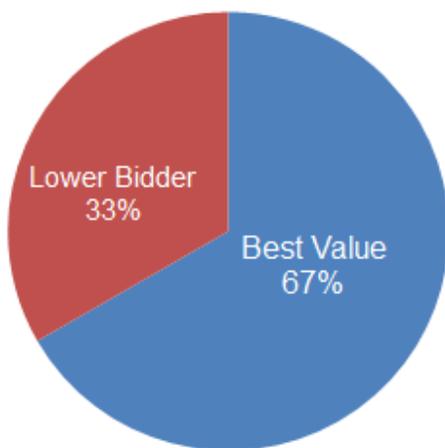
10- What is the commonly used procurement method?



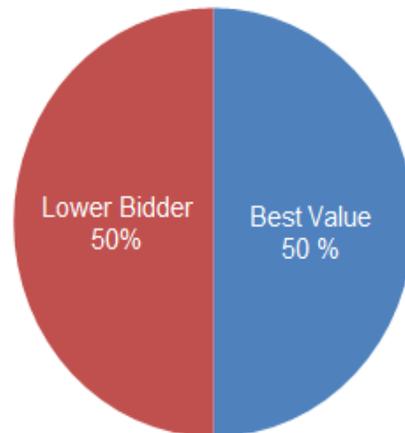
IPD & Bidding strategy



DB & Bidding strategy

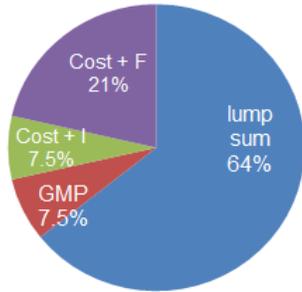


DBB & Bidding strategy

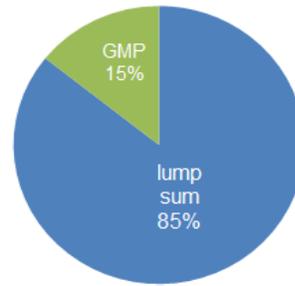


CMAR & Bidding strategy

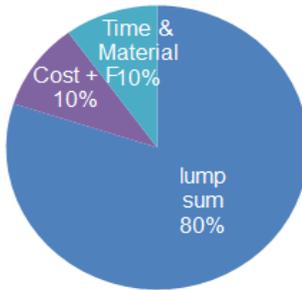
11- Which type of contracts is commonly used?



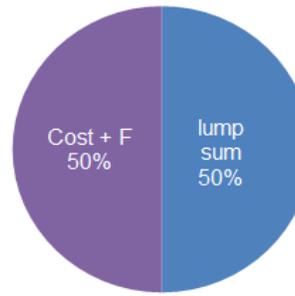
IPD & Contract type



DB & Contract type

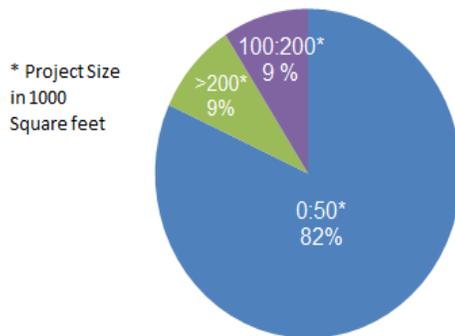


DBB & Contract type

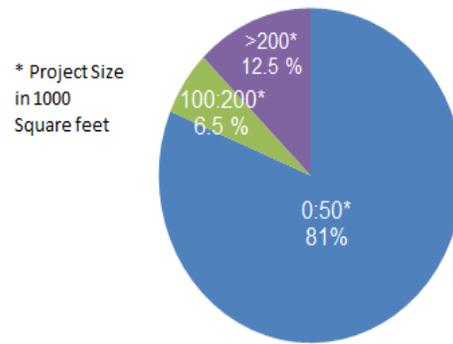


CMAR & Contract type

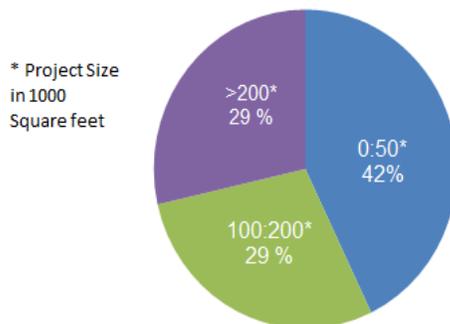
12- What is the total square footage of your project?



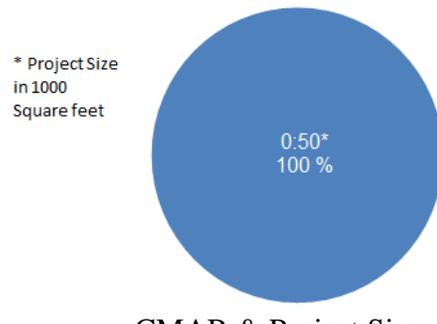
IPD & Project Size



DB & Project Size



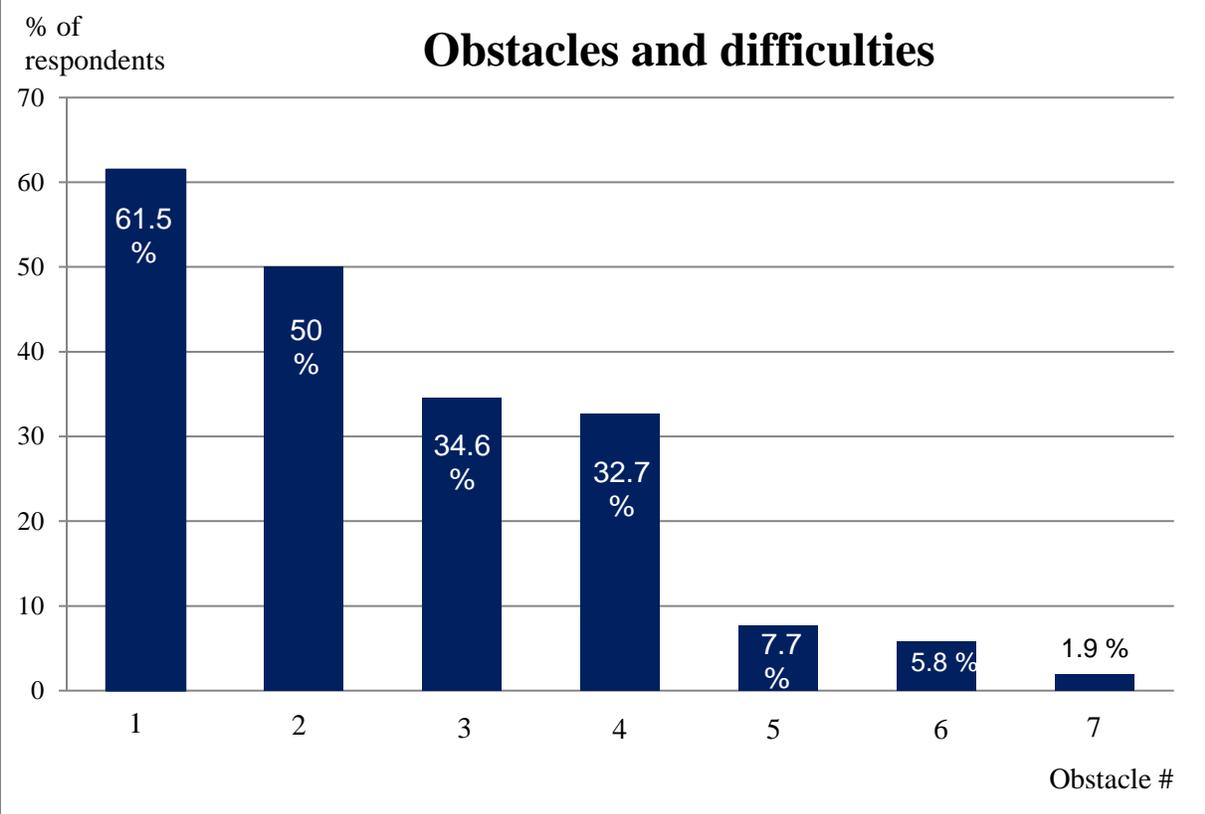
DBB & Project Size



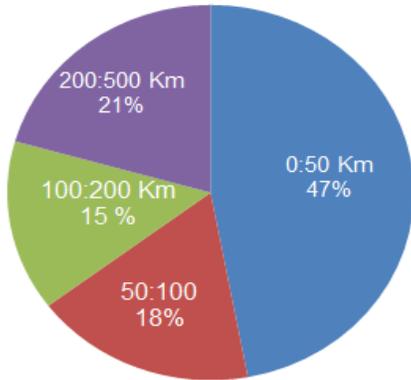
CMAR & Project Size

13- What are the obstacles and difficulties that you faced on your project?

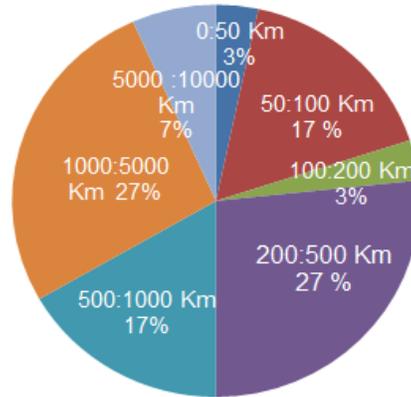
The obstacles and difficulties are ranked depending on the percentage of respondents as follows: 1) Contractors experience is not enough in applying modularization concepts (61.5%) , 2) Design scope was not be frozen early in project schedule (50%) , 3) Onsite and offsite schedules were not synchronized (34.6%) , 4) Module envelope limitation (dimensions limitation) restricted architectural design (32.7%), 5) Scheduling method utilized was not suitable for the project (7.7%), 6) Selected project delivery system was not suitable for the project (5.8%), 7) Attitudes of public inspectors (1.9%).



14- What is the commonly experienced distance between manufacturing facility and project construction site? Please specify: from km to km

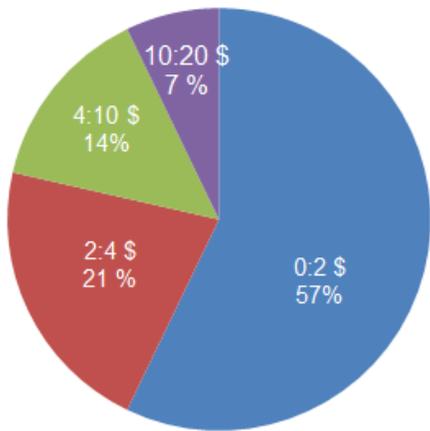


Minimum Distance

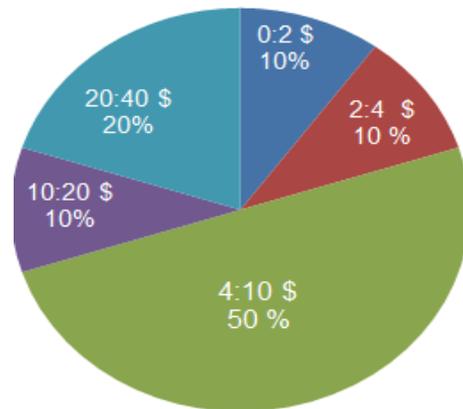


Maximum Distance

15- What is the average transportation cost per module square footage?

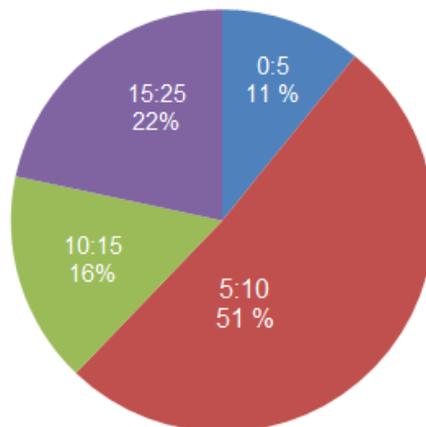


Transportation cost per module square footage (minimum distance)

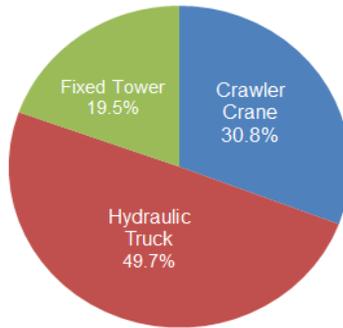


Transportation cost per module square footage (maximum distance)

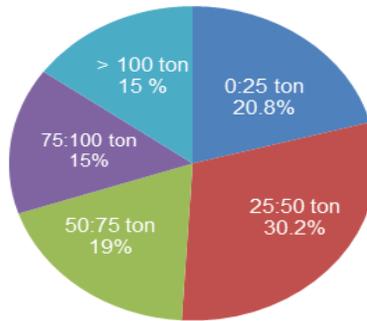
16- How many modules the cranes lift per day onsite (daily placing rate)?



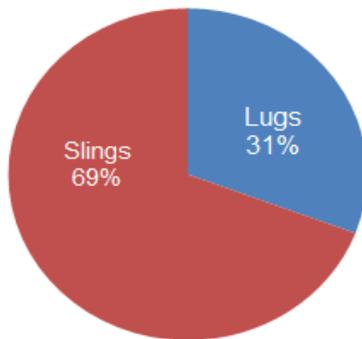
17- What is commonly used crane type in lifting modules on your projects?



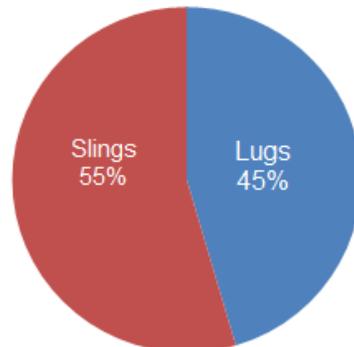
18- What is the average lifting capacity of the used crane?



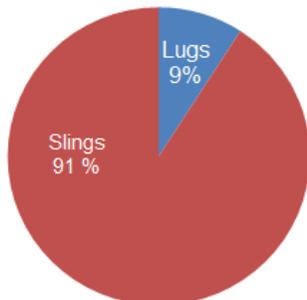
19- How is the module hoisted?



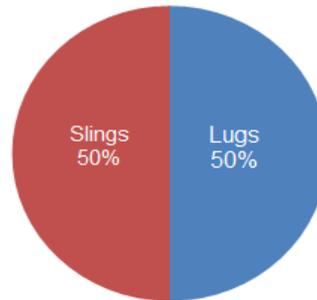
IPD & Module hoisting



DB & Module hoisting

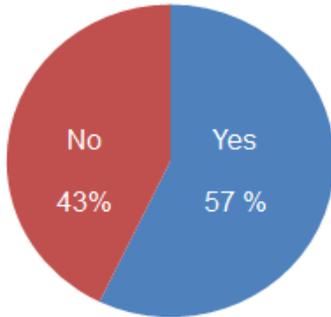


DBB & Module hoisting

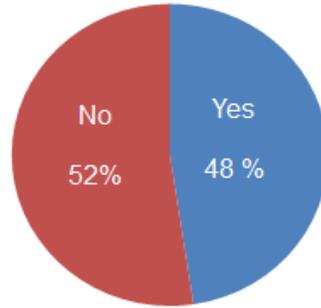


CMAR & Module hoisting

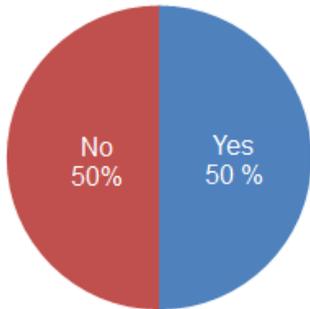
20- Is BIM used in your company?



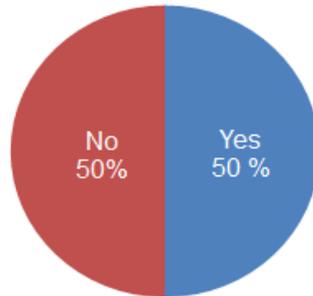
IPD & BIM



DB & BIM

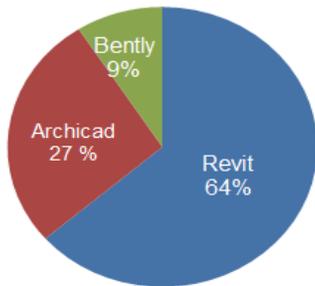


DBB & BIM

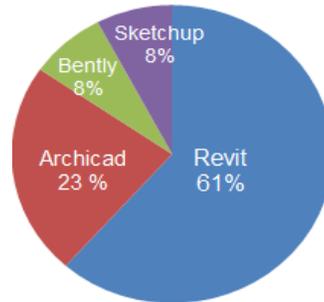


CMAR & BIM

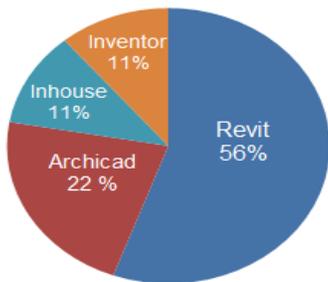
21- Which BIM software system is used in your company?



IPD & BIM Software

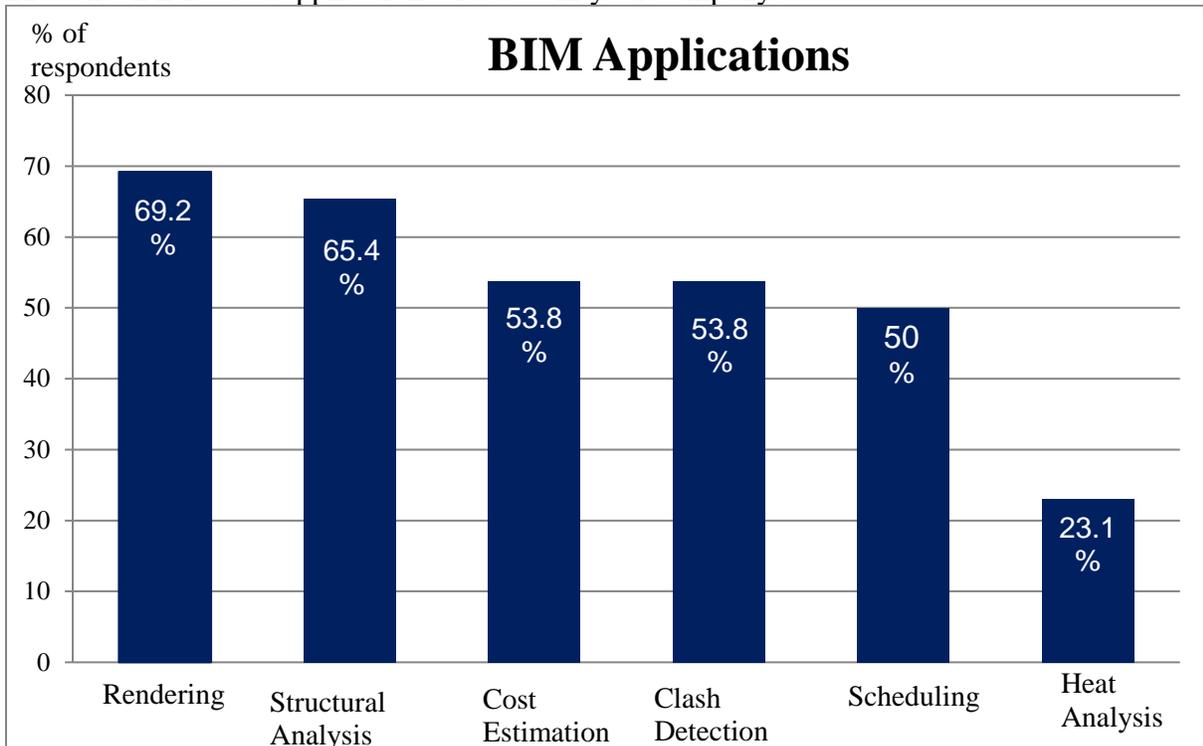


DB & BIM Software

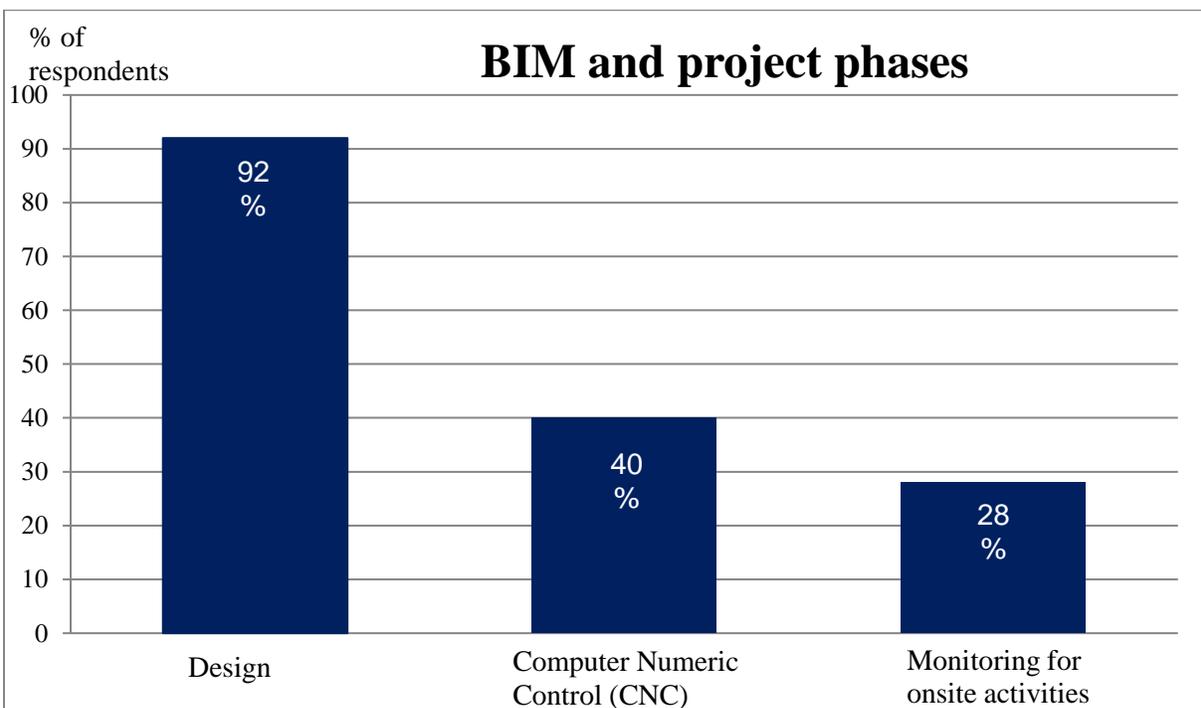


DBB & BIM Software

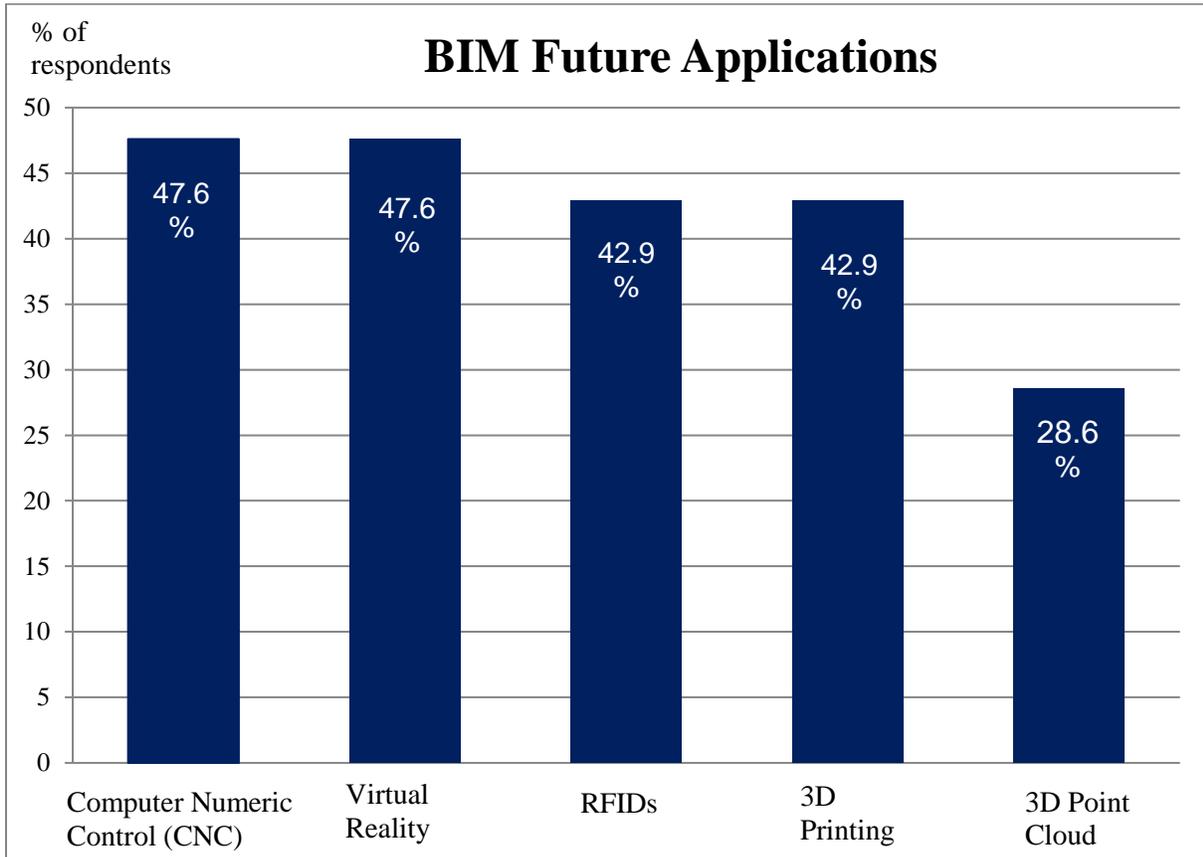
22- What BIM based applications are used in your company?



23- In which project phase BIM is used your company?

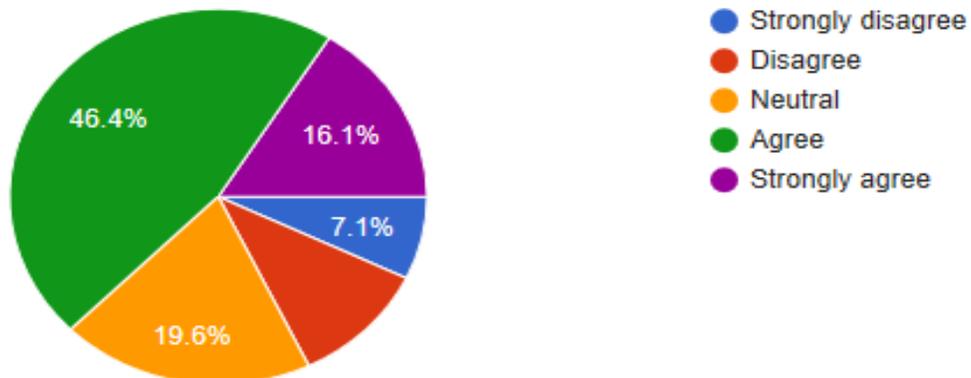


24- What future applications of BIM you are considering in your company?

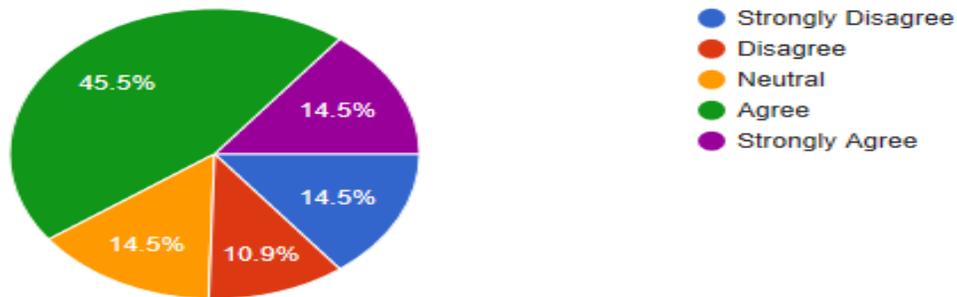


B- Second part - (Barriers to increased market share):

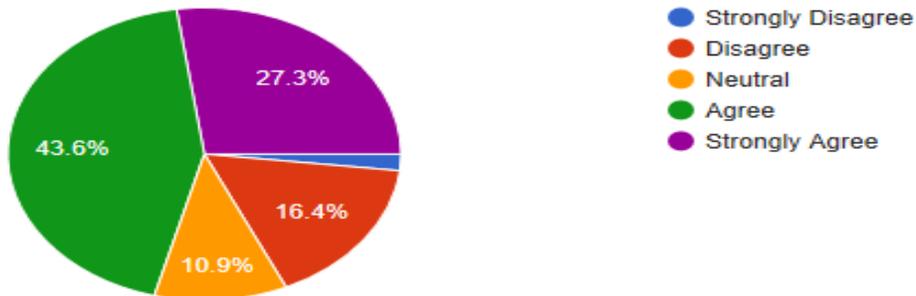
1. Do you agree with the following statement: "There is a negative stigma associated with modular and offsite construction"?



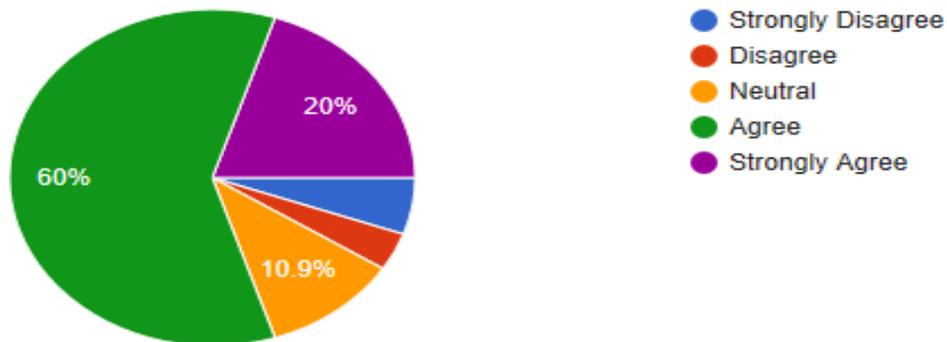
2. Do you agree with the following statement: “There is a misconception that modular is intended primarily for temporary, single-storey applications”?



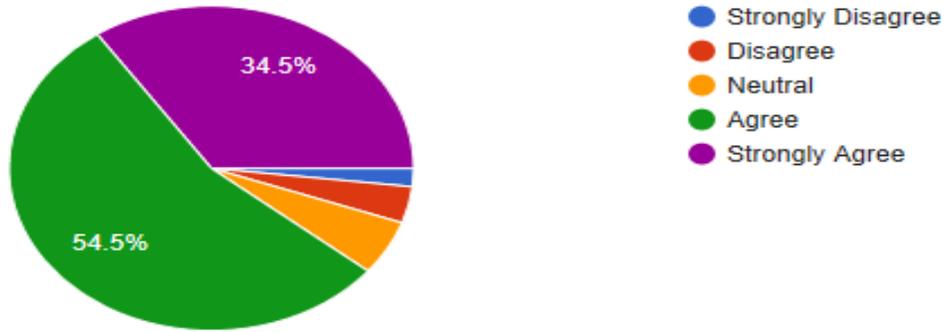
3. The significant advantages modular construction offers are not communicated properly with owners.



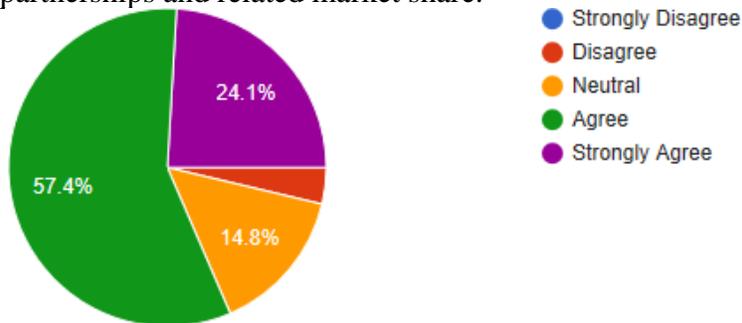
4. There is a shortage of well-designed marketing campaigns conducted by modular institutions and manufactures.



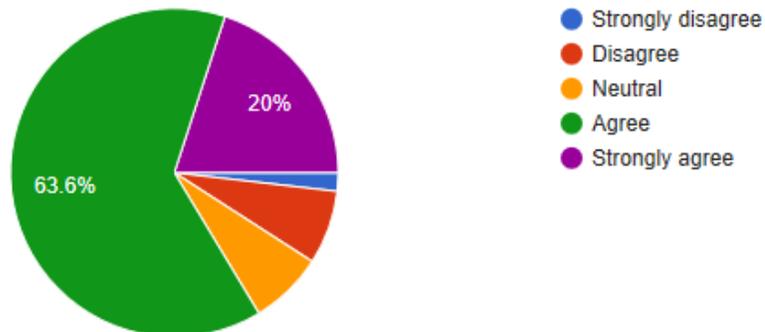
5. Owners are not familiar with the different products offered by the modular industry.



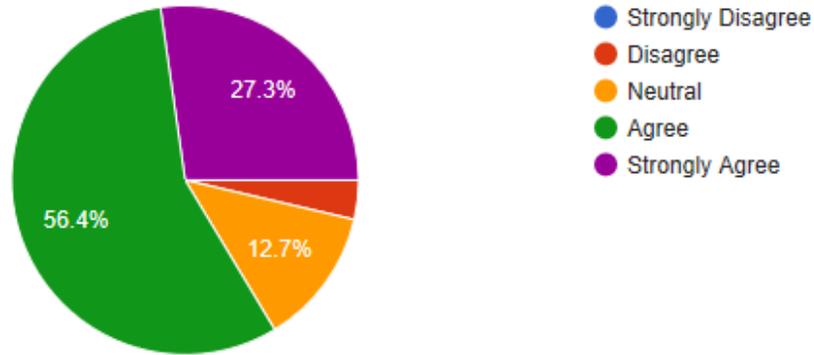
6. Due to the focus of modular manufacturers on local markets, the modular industry lacks large scale partnerships and related market share.



7. There is a lack of academic research that highlights the advantages of modular construction in comparison with the conventional construction methods.

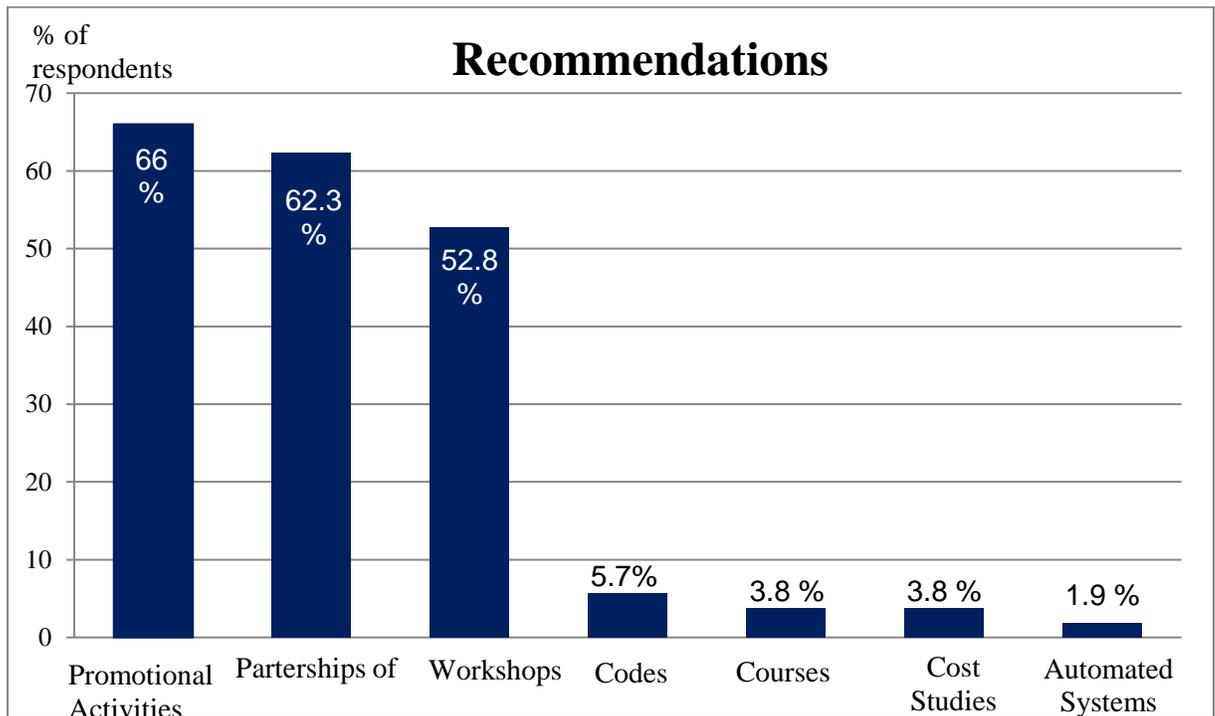


8. Modular manufacturers and institutions should organize regular facility visits open to the public to increase awareness.

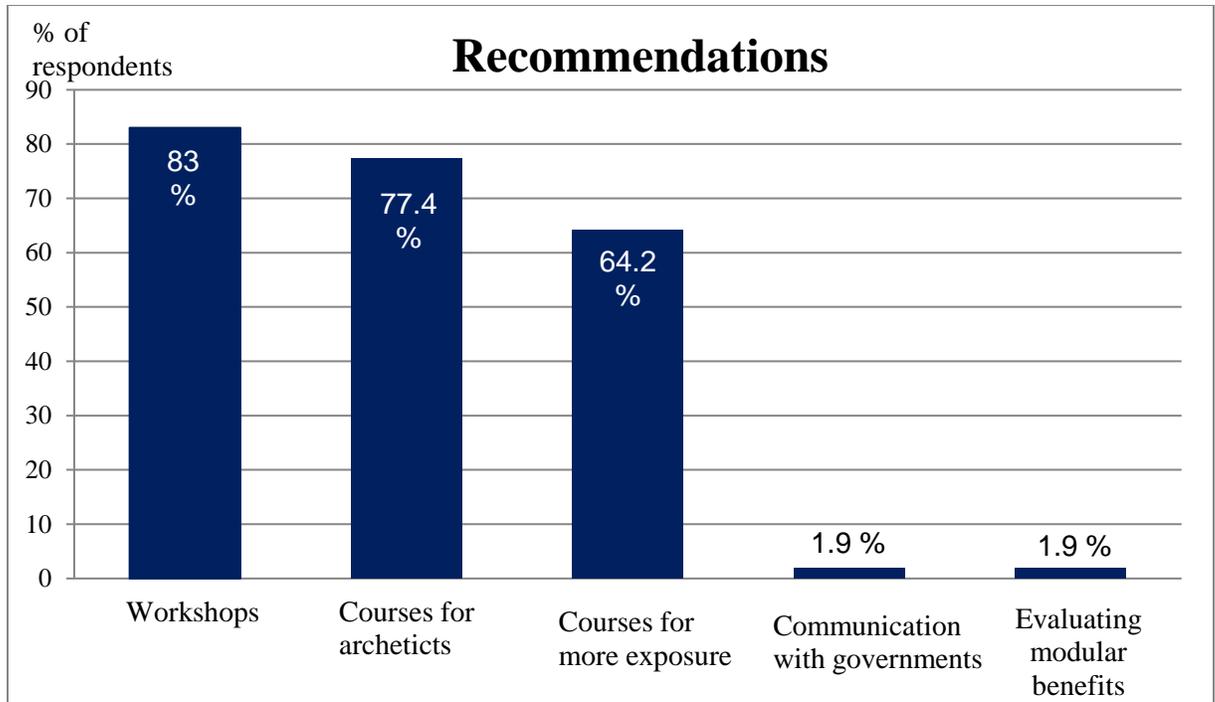


9. What do you recommend MBI, PreFab Australia, PreFab NewZealand and other modular-focused organizations do to remove the stigma of modular construction?

The recommendations are as follows: 1) Promotional activities such as a formal campaign as Go RVing (66%) , 2) Establishing partnerships among manufacturers (62.3%) , 3) Organizing special workshops (52.8%) , 4) Communicating with authorities to have the building codes changed to improve industry standards between manufacturers (5.7%), 5) Establishing specialized courses for architects and students (3.8%), 6) Disclosing cost and schedule savings studies and optimization due to utilizing modular construction (3.8%), 7) Utilizing automated systems more (1.9%).



10. What do you recommend research institutes and universities do to remove the stigma of modular construction?



11. What activities, events, or specialized conferences, such as the Modular and Off-site Construction (MOC) Summit and World of Modular, must be organized, other than what exists, to remove the stigma?

- a- Conducting international cooperation for all parties in the modular construction industry to show the American and Canadian ideas to the European industry and vice versa, and documenting the outcome as an open source format for everyone to share.
- b- Conducting seminars and workshops through NGOs and governmental bodies.
- c- Offering university and training courses for modular construction.
- d- More collaboration between modular participants and outside organizations.
- e- Engaging industry and academic partners in a strategic planning for research and development of modular construction to promote the implementation of research outcomes in the industry.
- f- Organizing factory visits for clients.
- g- Establishing a North American advertisement campaign for the modular construction supported by an explanatory website.
- h- Conducting local events for modular construction for the community.

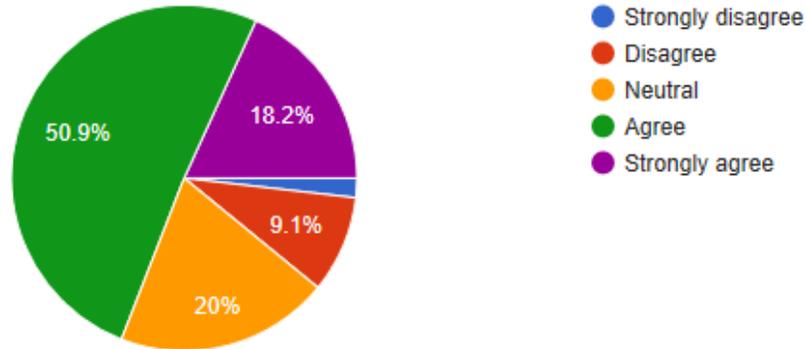
12. Would publicized success stories of modular be helpful in addressing the issue raised in 11 above?

Most of responses agreed that the publicity for modular is helpful and the following comments were added:

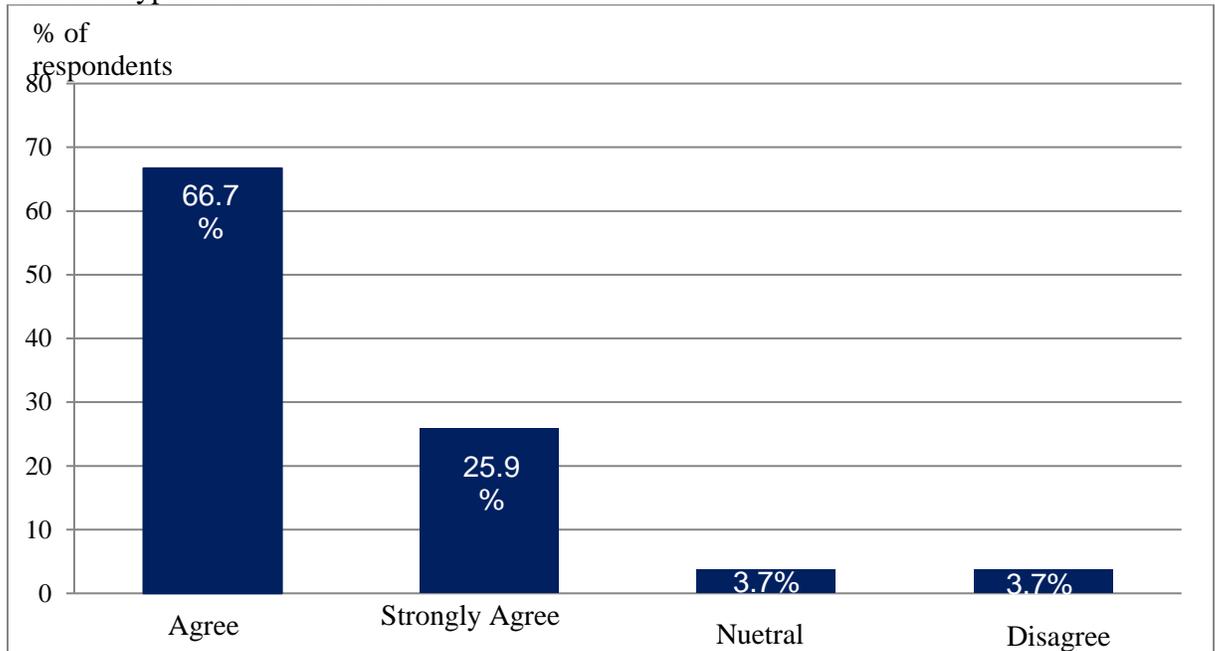
- a- Focusing on marketing by properly communicating the pros and cons of modular construction in terms of quality, environment, flexibility in design, and return of investment (ROI).

- b- Increasing the accessibility of information and training for the public regarding modular construction.
- c- Focusing on the idea that modular construction reduces the risk for clients and contractors instead on showing how the modular design is innovative.
- d- Improving academic-industrial communications and visits.

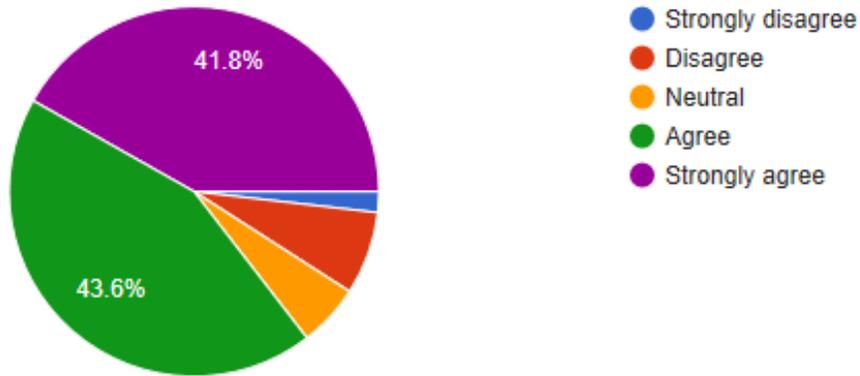
13. Modular construction lacks promotional materials that depict the successes and advantages.



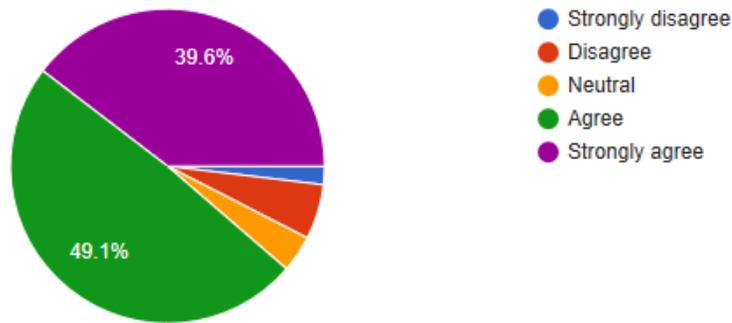
14. Owners lack knowledge about the compatibility of modular construction with different structure types and materials.



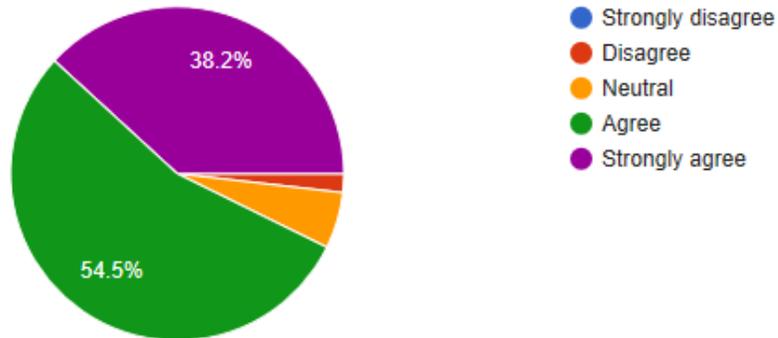
15. There is a lack of worldwide documentation for lessons learned in modular construction.



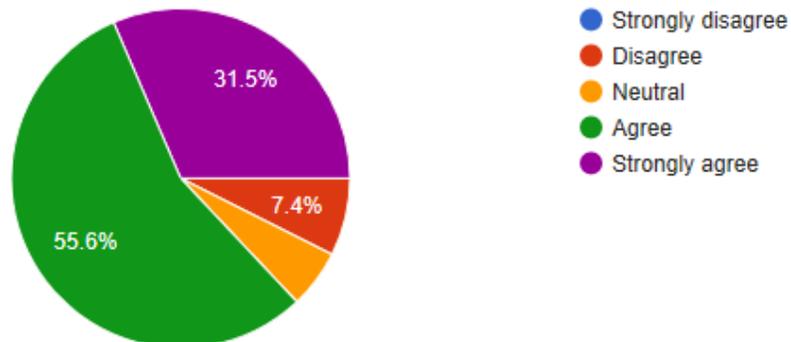
16. There is a lack of nationwide documentation for lessons learned in modular construction.



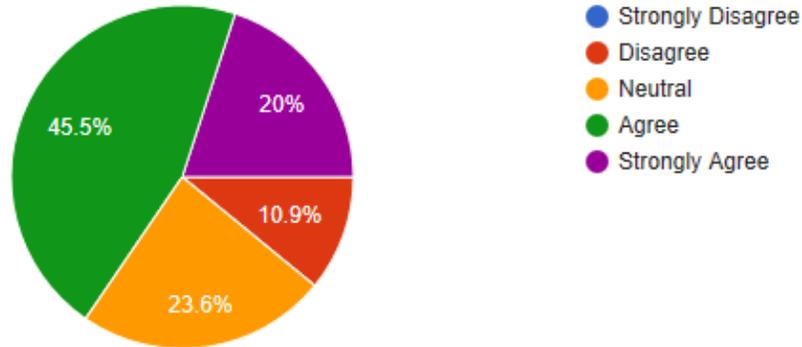
17. There is a lack of government-sponsored case studies to highlight obstacles and opportunities for modular construction.



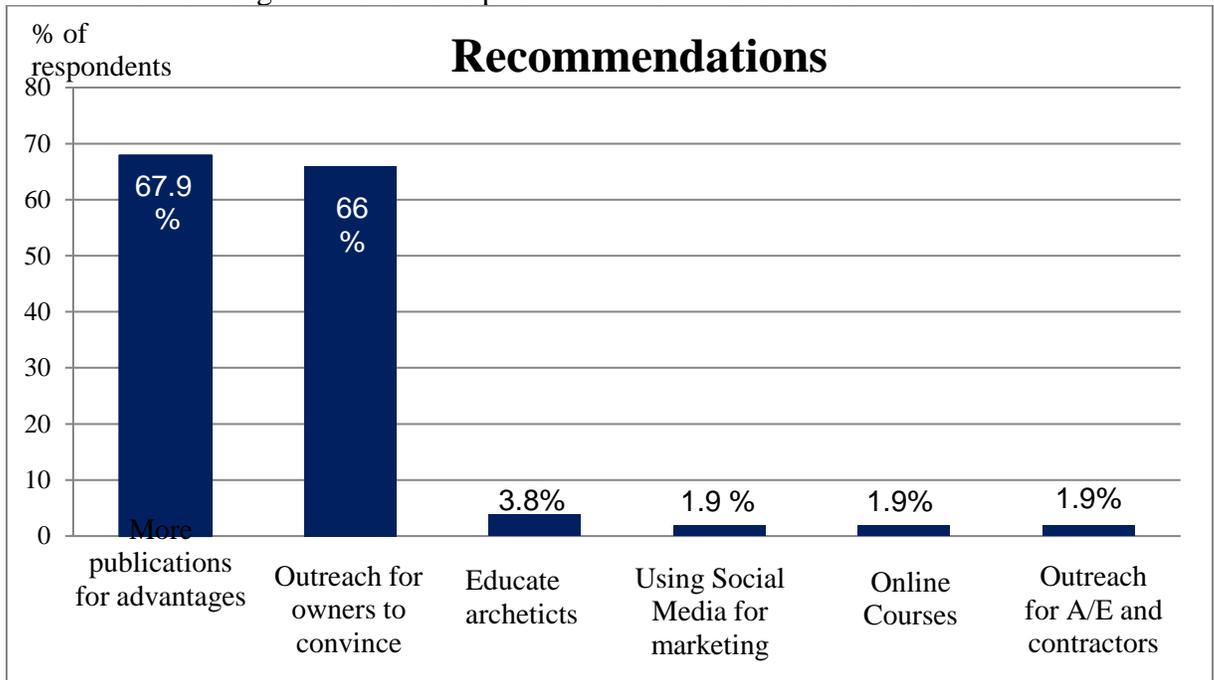
18. There is a lack of academic research that leads modular construction by identifying potential obstacles and opportunities.



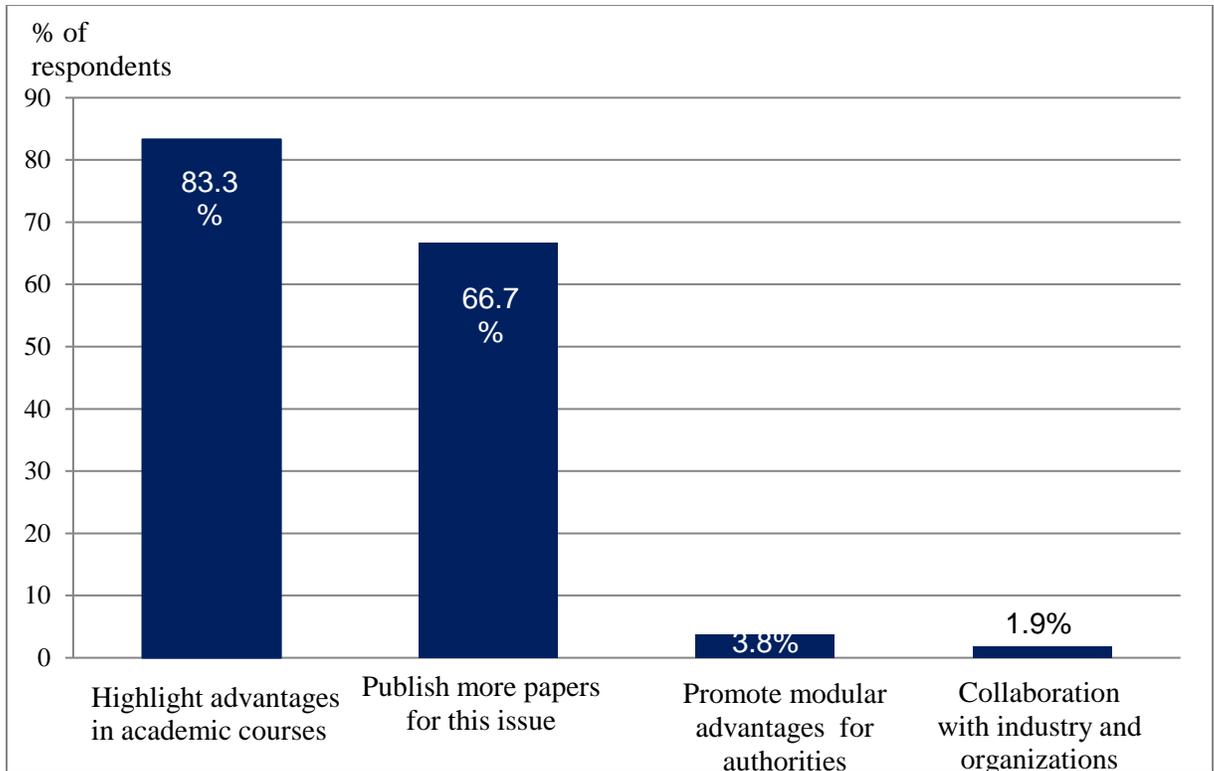
19. Data available for manufacturers and owners does not support decision making with a high level of confidence.



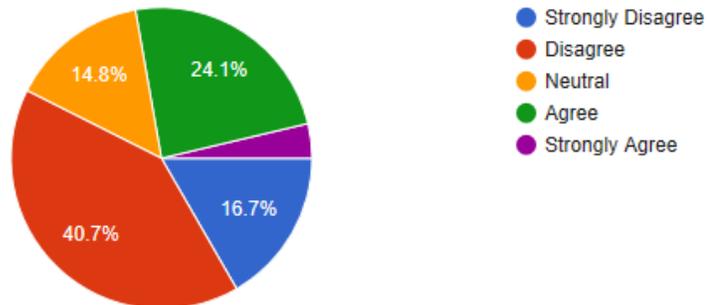
20. What do you recommend MBI, PreFab Australia, PreFab NewZealand, and other modular-focused organizations do to publicize the success stories of modular?



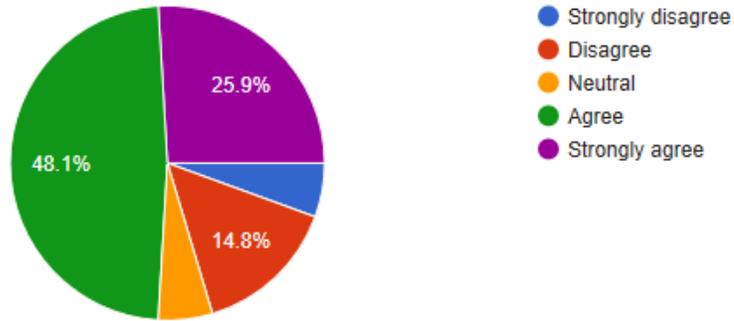
21. What do you recommend research institutes and universities do to publicize the success stories of modular?



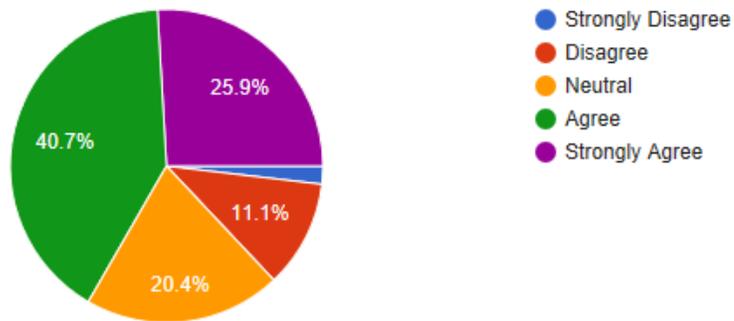
22. Existing regulations and by-laws are not obstacles for the modular industry.



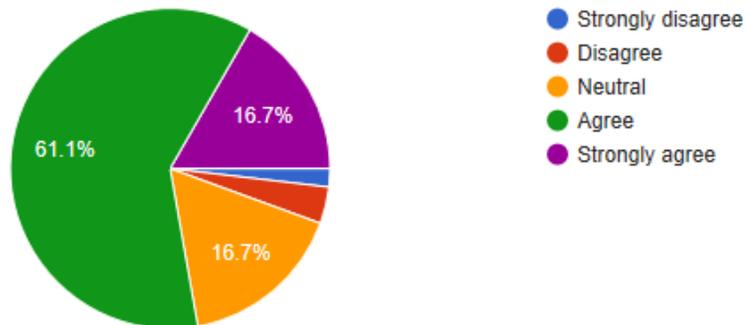
23. Although the existing regulations do not affect modular construction, the culture of inspectors, regulators, operators, etc. may place an extra burden on manufacturers.



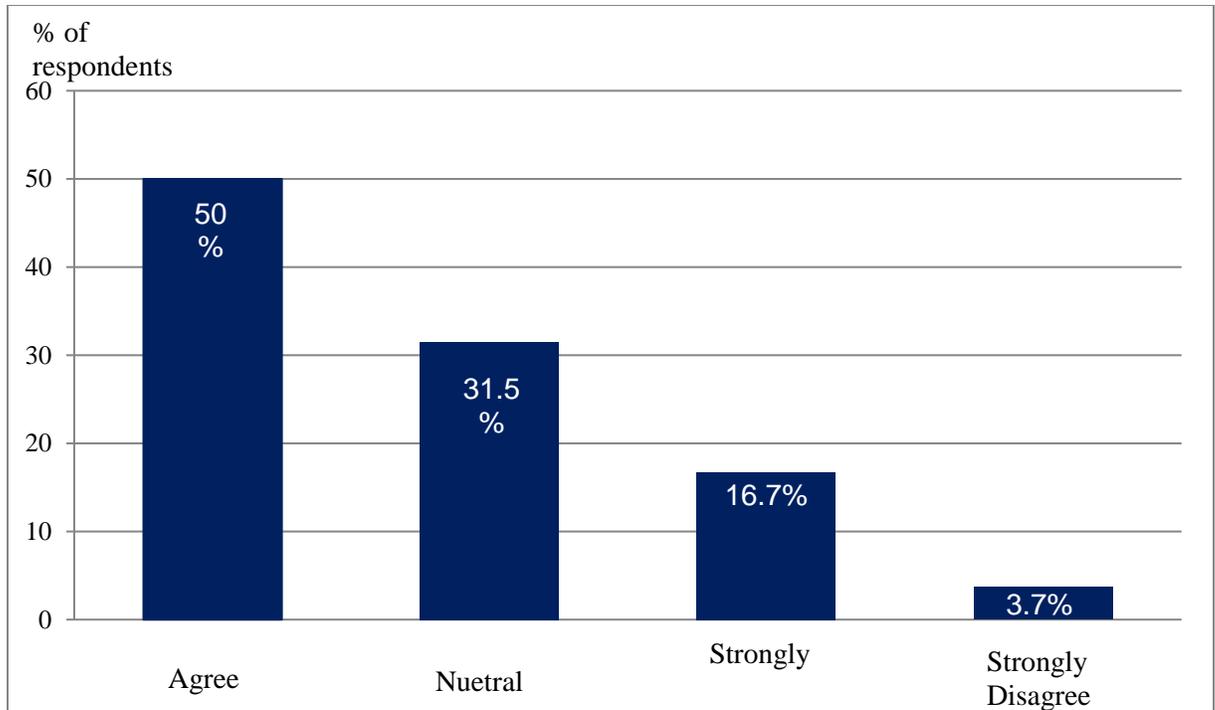
24. Transportation regulations significantly affect the cost, time, design, etc. of the modules, and therefore burden the modular industry.



25. The changes of regulations among the different jurisdictions complicate the delivery of modules.



26. Regulations and by-laws should account for the different nature of the modular industry compared to conventional construction.



27. What do you recommend MBI, PreFab Australia, PreFab NewZealand, and other modular-focused organizations do to incorporate modular construction within the current standards and regulation?

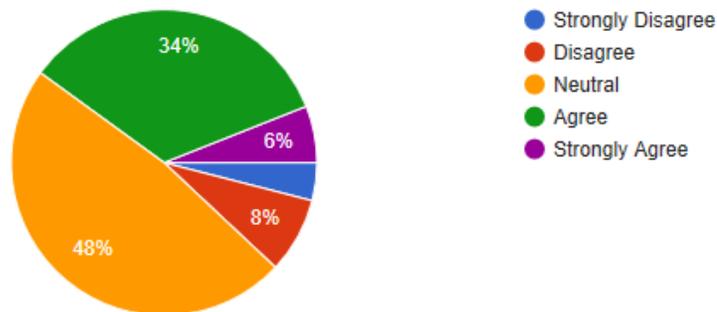
- a- Modular construction needs its own code.
- b- Coordinate with code agencies to release uniform codes which are applicable across multiple jurisdictions that adopt modular and non-modular updates.
- c- Adapting to current codes is better than having separate code standards which adds to the excuses contractors use against modular.
- d- Lobbying for modular friendly regulations.
- e- Contacting governments at all levels to promote/demonstrate through documented research the benefits of modular construction.
- f- Work with (not against) existing advocacy groups for construction (i.e. NAHB).
- g- Reaching the right people to make the needed changes.
- h- Educating inspection community of modular construction.
- i- More research and developments for modular construction.

28. What do you recommend research institutes and universities do to incorporate modular construction within the current standards and regulation?

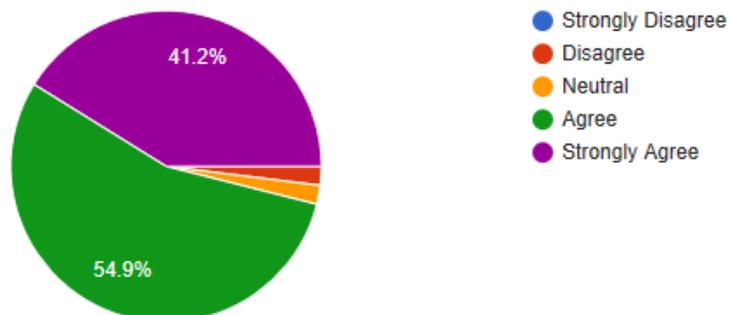
- a- Engineering departments should incorporate modular in their standard courses.
- b- Finding the gaps between modular construction and current standards.
- c- Develop research that ties the codes and standards with theoretical background of modular construction.
- d- Introduce modular concepts to architectural departments.
- e- Support lobbying for modular with case studies and data.
- f- More research and developments and local outreach.

29. What activities, events, or specialized conferences, such as the Modular and Off-site Construction (MOC) Summit and World of Modular, must be organized, other than what exists, to incorporate modular construction within the current standards and regulation?
- a- Review the UK growth in modular construction and adopt policies of marketing there.
 - b- Create events for owners, designers, contractors, and code inspectors.
 - c- Creating facility tours and project reviews like the UK www.buildoffsite.com.
 - d- Creating conferences in manufacturing facilities to show the full steps of modular construction.
 - e- Technical workshops to develop standards that are locally relevant and can be trusted by all stakeholders.
 - f- Developing standards are more important than promotional events.
 - g- Reach out to make presentations in other trade and professional associations.

30. Modular construction imposes changes in the perception of ownership. For instance, the purchaser holds the full ownership of the module.



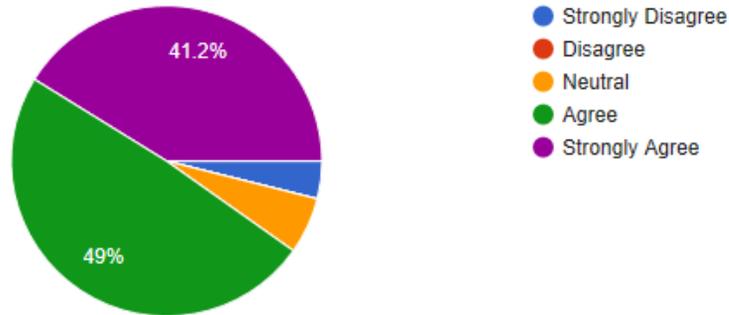
31. Due to the nature of the modular industry, the project execution plan has to be communicated up front and incorporated in the bidding process.



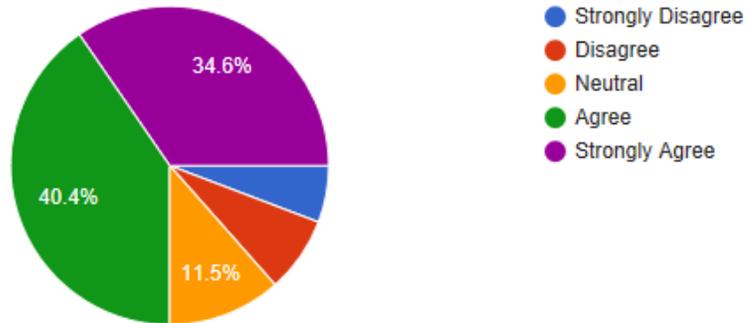
32. How can MBI, PreFab Australia, PreFab NewZealand, and other modular-focused organizations help to overcome the issues associated with procurement for modular construction?
- a- Focusing on financing and insurance by studying the solar/renewable energy industries for examples of innovative financing and insurance solutions.
 - b- Increasing the credibility of suppliers. The problem in Australia that there are no suppliers left! Clients want to utilize modular but they can't find a credible supplier.

- c- Developing codes and standards that consider procurement regulations for modular construction.
 - d- Implementing proper supply chain strategy.
 - e- By working on the biggest two issues on this regard, first is financing because lenders are afraid of losing value, the second is explaining the added value of modular manufacturing to the retail consumers.
 - f- Working with the industry and train companies to develop appropriate plans and approaches.
33. How can research institutes and universities help to overcome the issues associated with procurement for modular construction?
- a- Analyze/measure/test/confirm the responses to this survey and distribute the results to stakeholders including debt lenders, equity/preferred equity/mezzanine equity providers, real estate investors/equity partners, real estate developers/builders/general contractors/sub-contractors/materials men-suppliers/design consultants e.g. architects, structural engineers, LEED/equivalent raters, ADA/Fair Housing reviewers, water intrusion consultants, civil engineers, traffic engineers, geotechnical engineers, environmental engineers, fire-safety engineers, sustainability/IT professionals, MPE engineers, Healthy-building/Well-building professionals, sub-metering systems providers, building code/compliance professionals, all manner of governmental subdivisions including their planners, plans reviewers, building inspectors, on/off-site improvements professional, transportation systems professionals, all utility companies/service providers, property/asset management professionals. Any/all of those have a stake in the product/end product.
 - b- Contractor's perception about 'buying' research need to be enhanced.
 - c- Develop new modular construction procurement methods that account for the characteristics of modular construction.
 - d- Value engineering with modular construction should be a course.
 - e- More research and publications which can be used to demonstrate the value of automated production, quality control, strength versus stick built.
 - f- By conducting economic research and analysis for modular construction.
34. What activities, events, or specialized conferences, such as the Modular and Off-site Construction (MOC) Summit and World of Modular, must be organized, other than what exists, to help overcome the issues associated with procurement for modular construction?
- a- One big event rather than smaller less focused shows. The PreFab Australia annual conference has become a farce and is now devaluing modular in AU/NZ. PreFab NZ are really good but suffer, as AU does, from a lack of independent case studies of any scale. Australia is particularly self-interested and as such we do not attend. World of Modular - much better. Do one in Hawaii and we'll meet half way!
 - b- Utilizing social media promotion and long term commitment to promotion similar to the "Go RVing" campaign.

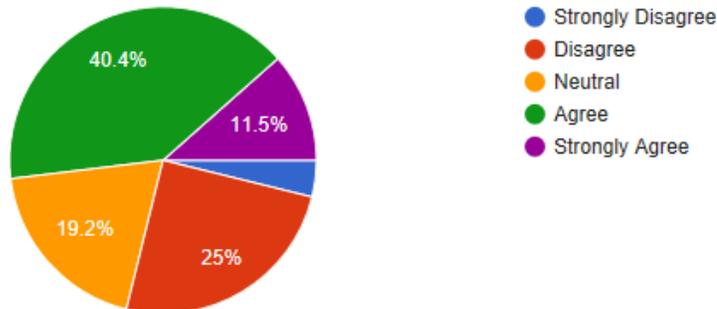
35. The predictability of cost and schedule gives the modular industry an advantage over the conventional construction.



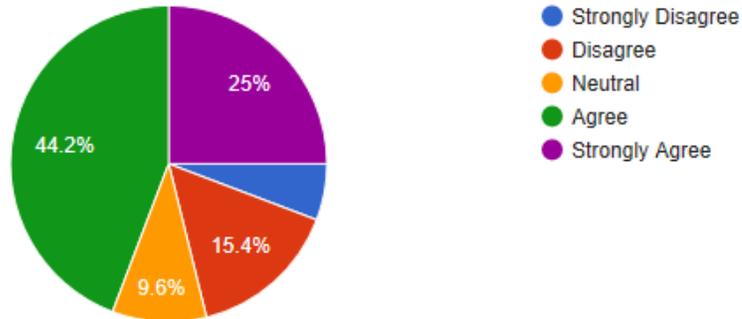
36. The lower level of risk associated with modular construction has to encourage stakeholders to adopt new payment methods that are different from conventional construction.



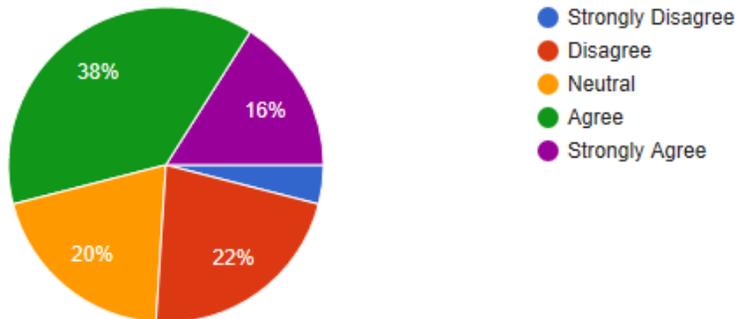
37. The module belongs to the owner the moment it is fabricated, and therefore the owner should be responsible for the cost associated with storage.



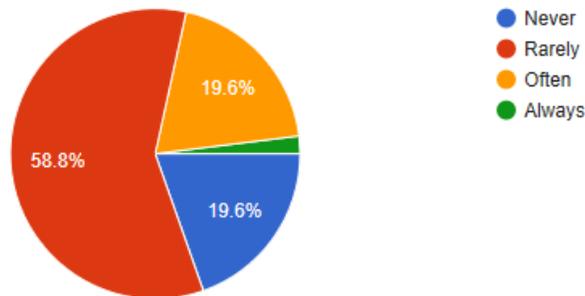
38. If the module is fabricated on time and ready to be delivered to the owner, and for any reason it cannot be delivered to the site upon owner's request, the owner should be responsible for the cost associated with storage.



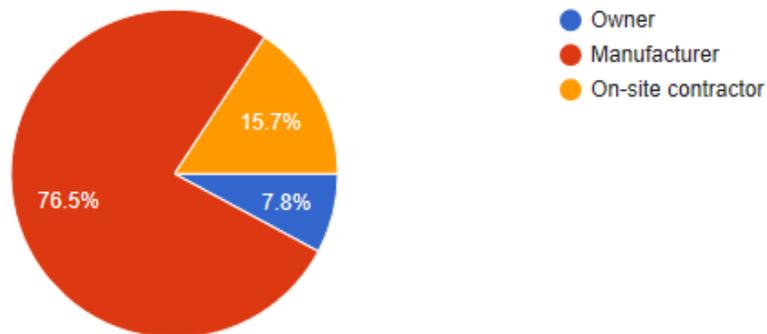
39. If the module is not assembled, it is the manufacturer's responsibility to pay for any cost associated with storage.



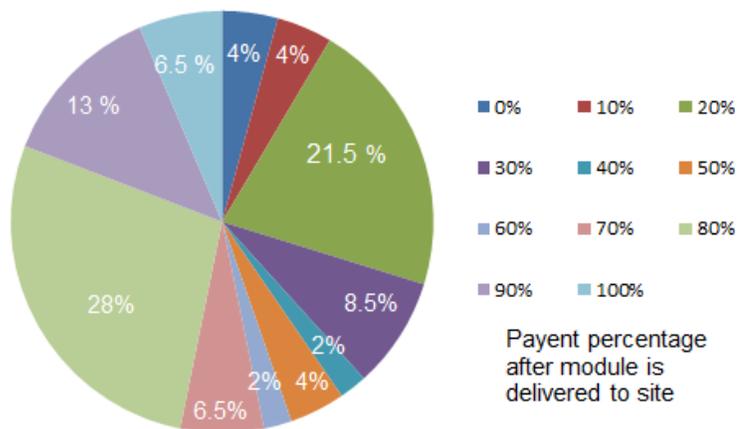
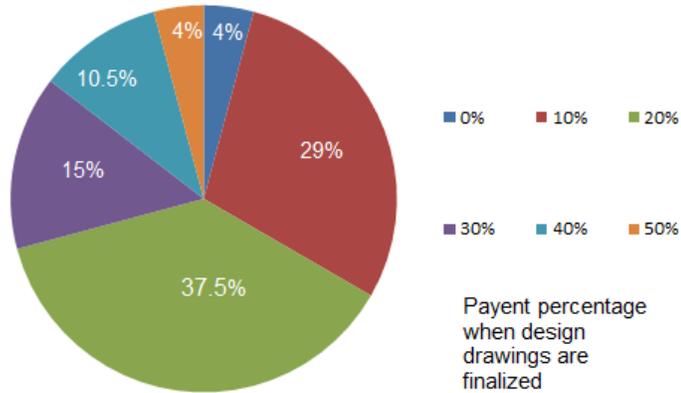
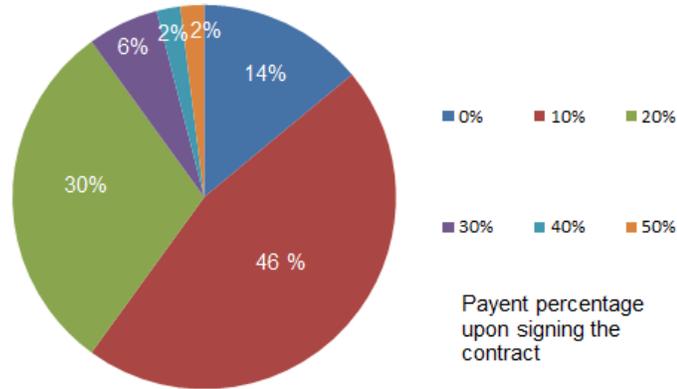
40. How often in your past projects did you have a problem with the delivered modules because they were different from the design specifications leading to difficulties in the installation process?

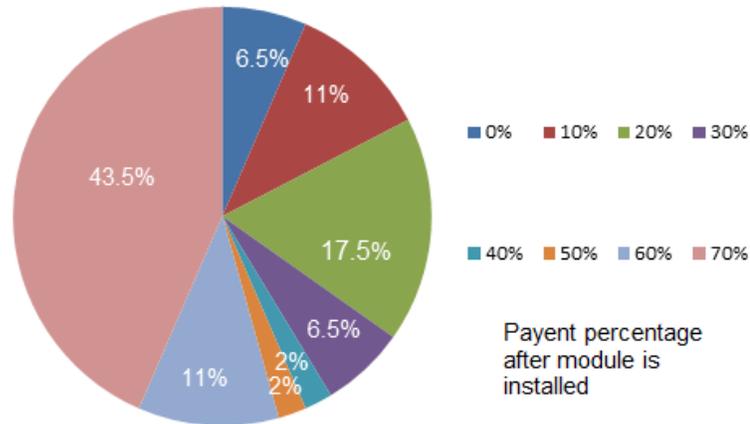


41. If a delivered module is not in full compliance with its design specifications and it does not fit at its final location onsite, who do you think should be held responsible for associated extra costs, e.g., storage, extra measures to fix the problem.



42. Please indicate a percentage of the full contract price for each of the following progress levels that you think would be a fair guide for determining **the progress payments to the manufacturer?**





43. How can MBI, PreFab Australia, PreFab NewZealand, and other modular-focused organizations help to overcome the issues associated with project financing for modular construction?
- Forcing finance markets to create models that consider modular construction characteristics.
 - Explaining for lenders why the manufacturing site is same as construction site for stored materials. It is the lending institutions that cause the issues for the owner since many do not understand modular industry.
 - Partnerships with financing houses.
 - Creating lending institutions for modular construction.
 - In the case of the Modular Housing Association Prairie Provinces (MHAPP) members, Retail Sales Centres pay the manufacturer the full wholesale price for production of the module at the time the sales centre picks up the module from the manufacturer. Unless special financing is arranged between the manufacturer and the sales centre. The sales centre then sells the module to the end consumer - it is this part that requires a change at the lending institutions - where upon once the home is delivered 85% of retail price is remitted to the sales centres with the 15% hold back released upon connection of utilities - if the sale centres does more extensive site work, an advance should be provided prior to delivery of the home.
 - Educate financial institutions as to the risk reduction inherent in modular construction vis a vis stick built construction.
 - Getting banks to change lending policies.
 - Major insurance companies should insure modular buildings at a lower rate, if we can prove to them they are better build. I believe Loyd of London does this in UK. Why we cannot implement this in the USA and Canada.
44. How can research institutes and universities help to overcome the issues associated with project financing for modular construction?
- Help customize the standard Construction Contract to the MOC System.
 - Educating upcoming potential construction leaders and having them understand the concept of modular and the great control of costs and tighter fixed costs.
 - Design a lending loan program for modular construction.

- d- Develop cost management method that account for the modular construction characteristics.
 - e- Education and quality acceptance is key for all parties associated with project development from Governments to Architects, Planners, lenders, insurance companies, lawyers and real estate agents.
 - f- Provide studies that document risk mitigation with modular.
 - g- Create awareness of the quality of the automated production line manufacturing of housing and commercial structures and the benefits which are many, conduct research about how they withstand hurricane force winds better than site built construction. There are so many attributes that the public, contractors, builders, and developers don't understand about Modular construction such as less interest carry due to shorter construction periods.
45. What activities, events, or specialized conferences, such as the Modular and Off-site Construction (MOC) Summit and World of Modular, must be organized, other than what exists, to help to overcome the issues associated with project financing for modular construction?
- a- Special summits to lenders.
 - b- Train modular industry professionals to understand and incorporate provisions in their proposals/agreements that are standard/legally required of borrowers/developers/general contractors. Stop wasting time with agreements that won't possibly be approved by project capital providers.
 - c- Inviting government officials, architects planners lenders, insurance companies, lawyers and real estate agents to attend such events.
 - d- Train and setup banks to finance modular products. Because lenders are afraid that the product value isn't retained.