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The Study of Modular Construction System (MCS) Application for Affordable Housing in Malaysia

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Abstract: Modular Construction System (MCS) in some developed countries is defined as a Modern Method of Construction (MMC) or Offsite Fabrication (OSF). The use of robotic and automated technologies in MCS still not gain so much popularity among construction building players. This paper discusses the understanding MCS among the construction company in Malaysia, the challenge faced to adopting robotic technologies in MCS, and method improvement implementation of robotic technology in MCS among Malaysia construction industry. Qualitative and quantitative research was conducted in this research. G7 construction company at Johor Bahru was been respondent in this research. A questionnaire (79 respondents) and a semi-structured interview (5 respondents) had participated in this research. Descriptive analysis (SPSS) and thematic analysis using in this research to analyse data have been collected from questionnaire form and interview form. From the data analysis result, most of the respondents have knowledge and understanding about the MCS. Furthermore, the cost can be the main challenge in the MCS to applying robotic technology. Also, some of the methods that have been identified can be used to improve the application of robotic technology in MCS among the G7 construction company in Johor Bahru. This research can provide the knowledge of the MCS, grasp the challenge faced in robotic technologies and understand which initiative method can overcome challenges in the MCS.

Keywords: Affordable Housing, Modular Construction System (MCS), Robotic and Automated Technologies

1. Introduction

Modular Construction System (MCS) also known as a house is manufactured in a factory and produced in a module (Aziz *et al*., 2015). In Malaysia, MCS can be defined as off-site construction which takes place at a factory specifically designed for this process, where individual modules or

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building components are built in the factory and then transported to the site for installation (Gibb, 1999). MCS is one of the innovative ways for the construction industry to solve the problem of sustainable design, rather than traditional construction (Abdullah, 2010). MCS ensures the quality building and promotes efficiency, sustainability, capability, and shorting project schedule (Musa *et al*., 2016). Malaysia housing becoming seriously unaffordable that has included some reasons including structural, cyclical, institutional, and cultural factors that ultimately lead to mismatches. Between supply and demand, housing has become severely abandoned in Malaysia in 2016. As a result, Malaysia faces a shortage of affordable housing (McKinsey, 2014).

1.1 Research Background

At the turn of the 20th century, American housing development promotes a structure that involving all the materials needed to build a prefabricated home known as "kit homes". After World War II in the 1950s, these prefabricated homes gained popularity, and these houses growing demands because at that time prefabricated homes can be built speedily and can easily be assembled. The first modular home was constructed in the way of a double-wide modular unit under local building code in 1958 (Broussard, 2017). In the Malaysia construction industry, Modular Construction System (MCS) is included in the Industrialized Building System (IBS) classifications which are involved in IBS precast concrete and IBS innovative systems. IBS can define as a structural building that is complete in prefabrication technique (CIDB, 2017).

1.2 Problem Statements

In Malaysia construction industry is still at an initial stage for adoption of modular construction systems (MCS), building players still less aware and experienced (Aziz *et al*., 2015). Malaysia MCS still lacks technology in the automation and robotic industry (Wong, 2018). Robotics and automation systems have the potential to address low efficiency and low productivity in the MCS industry. However, the adoption level of the construction industry is very low (Delgado *et al*., 2019). In Malaysia, the construction building sector still has not gained so much popularity in the automatic and robotic industries. Industry players prefer to use immigrant labor in the construction industry also is a factor contributing to using automation technology because of the lower labor cost rather than automation technology installation fee (Aziz *et al*., 2015).

The major obstacle that restricts works in prefab-system-based projects is the inadequate superior and high technology equipment and machinery (Nasrun *et al*. 2015). More specifically, Malaysia lacks design and engineering skills in prefabrication, while the construction industry continues to adopt traditional methods (Wong, 2018). In conclusion, based on Delgado *et al*. (2019), Aziz *et al*. (2015), and Wong (2018) Malaysia Company in MCS still lack adoption of robotic technology. Labor fee for immigrants is cheaper than installing robotic technology and the fee for installation and maintenance is expensive. This is causing Malaysia's construction industry to still lack automation and robotic technologies.

1.3 Research Questions

Based on the problem statements, following questions are posed:

(i) Which is the Malaysia construction company understand Modular Construction System (MCS) in affordable housing?
(ii) What will be the challenge in the Modular Construction System (MCS) to applying robotic technology in Malaysia's affordable housing industry?
(iii) What methods can be used to improve the implementation of robotic technology in the Modular Construction System (MCS)?

1.4 Research Objectives

Three objectives are established as accordance to the problem statement that has been identified.

(i) To identify the understanding modular construction system (MCS) among the construction company in the affordable housing industry Malaysia.
(ii) To identify the challenges of modular construction system (MCS) to applying robotic technology in Malaysia affordable housing industry.
(iii) To investigate the method improvement implementation of robotic technology in modular construction system (MCS).

1.5 Scope of the Study

The scoping study for this research was been selected in Johor Bahru, a cities second highly involved in MCS. According to CIDB Malaysia construction company had registered adoption MCS is located in three cities highly involved in MCS, first in Kuala Lumpur; second is Johor Bahru and third is Sarawak involving four registered companies in 2015 (Aziz *et al*., 2019). It is limited because of the low implementation rate of modular construction in Malaysia (Musa *et al*., 2017). G7 construction company selected to become respondents of questionnaires and for an interview in this study. Construction companies hold a G7 license approved by the Malaysian Construction Industry Development Board (CIDB) so that they can engage in unlimited civil engineering construction and housing construction projects (Nathan, 2015). This study carried out knowledge and application of robotic technology in MCS for affordable housing among Malaysia construction companies registered under the Malaysia Construction Industry Development Board (CIDB).

1.6 Significance of the Study

This study is important to gain an understanding of the application of Modular Construction System (MCS) in the affordable housing industry in Malaysia and can benefit builders, housing development, property buyers, government, and educators. Builders can gain more knowledge about the importance and benefits of implementing robotic technology in the Modular Construction System (MCS) construction industry. Housing development can take as a reference in their business strategy and management to improve their business. Property buyers can have an understanding of the reason that results in the trend of the housing market values and the housing market growth in the future. The government can encourage Malaysia construction industry players to use construction robotic technologies to improve the quality of the project. Educators can take as future references for researchers and educate the students.

2. Literature Review

2.1 Modular Construction System (MCS)

2.1.1 Definition of MCS

From the literature review, the inclusive definition of modular construction interprets as;

"Modular construction is a construction method that produces a building that consists of modular units or modules, mass-produce off-site in a manufacturing facility. It includes the logistic and assembly aspect of it, done in proper coordination with through planning and integration (Musa *et al*., 2014)."

2.1.2 Characteristic of MCS

The literature emphasizes some influences and basic characteristics of modular construction.

(a) Sustainable Method

The modular structure can greatly reduce the demand for raw materials and energy. Reducing excess material and being able to recycle modules can reduce waste (Robinson, 2019).

(b) Increase Project Schedule

Modules built in the factory and perform on-site basic work can reduce project time by up to half of traditional construction time (Musa *et al*., 2016). Figure 1 shows the modular construction schedule.

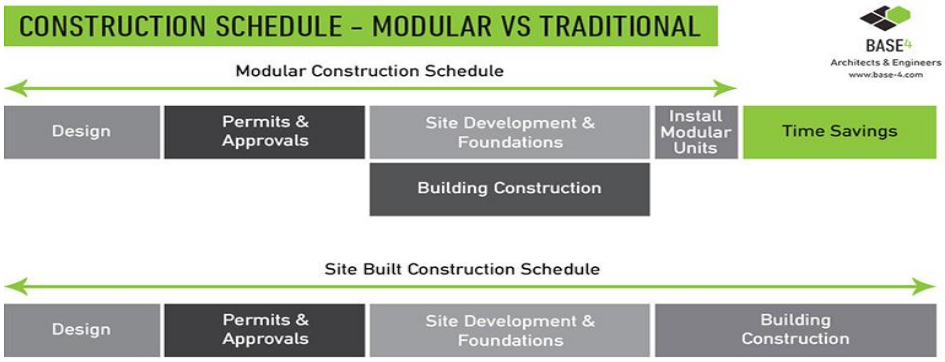

Figure 1: Modular Construction Schedule (Base 4, 2020)

(c) Easy to Disassembled and Reusable Construction Method

Reducing excess materials and recyclable modules can ultimately reduce waste from modular construction (Wong, 2018).

2.1.3 Process of MCS

MCS is an innovative and sustainable large-scale construction method that can achieve better results in reduced time and cost. Figure 2 shows the flow of the MCS process.

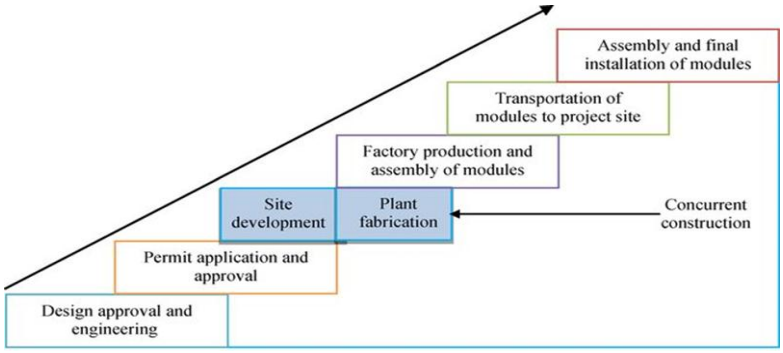

Figure 2: Modular Construction Process (Ibrahim *et al*., 2019)

2.2 Affordable Housing

Affordable housing has become a key issue, particularly in developing countries. Affordable houses consider when the price of housing is no more than 30% of household income, which means 25% of the income is for the affordable mortgage payment, another 5% of the income for other costs (Abdulateef, 2012).

2.3 Categories Construction Automated and Robotic Technologies

Four general categories of robotics are used in construction sites to improve productivity (Delgado *et al*., 2019).

(a) Off-site automated prefabrication system

Including activities by using automated manners to generate building components in remote locations. The main goal of these systems is to enhance the standard of prefabricated building components (Delgado *et al*., 2019).

(b) On-site Automated and Robotic System

Using during on the construction site. Robotic on-site can directly create structure and components of the building (Delgado *et al*., 2019).

(c) Drones and Autonomous Vehicles

Controlled remotely through a human-machine interface and can complete various tasks. It can be applied in the construction industry to improve communication, marketing, and safety (Ayemba, 2018).

(d) Exoskeletons

A wearable device that can be executed with a robot docked by a user, thereby automatically performing tasks that replace workers (Ruggiero *et al*., 2016).

2.4 Challenges of MCS in Robotic Technology for Affordable Housing

In Malaysia, the rarely using of robotic and automated technologies in the construction industry (Nasir *et al*., 2013). There were some challenges in the application of robotic technologies.

(a) Cost

High expense cost and expensive cost of the maintenance machinery needed to be affordable in improving and satisfying the needs of task performance (Akinradewo *et al*., 2018).

(b) Neoteric Method

Most construction workers have received training in the same industry and happened to specialize in the industry for many years, a neoteric method using let managers may wonder whether workers are capable of operating new robots and building automation (Akinradewo *et al*., 2018).

(c) Employee Employment Opportunities

Substitute labor will happen when robotic technologies are used in the construction industry (James *et al*., 2006). Workers affected will be required to change employment structures, as this will reduce the amount of work available (Akinradewo*et al*., 2018).

(d) Lack of Investment in Research and Development (R&D)

Many companies and practices in the industry do not participate in research and development. If contractors have difficulty in commercial R & D, they will not attract contractors the advantages of independent innovation (Brown, 1989).

(e) Investor Resource

Stronger companies have a higher chance to adopt or buy robotic technologies, this cause the small companies haven't promoted themselves into the market difficult to apply these technologies (Kamar & Hamid, 2009).

(f) Re-training of Worker

Employees who operate robots will be trained to enable them to interact with new robotic equipment, which will take time and cost to provide education to workers (Yahya *et al*., 2019).

(g) Lack of Space

Working in an untidy and chaotic place is difficult and will happen injured. Lack of space, it will be difficult to transport material and move from one location to another location (Heiskanen, 2014).

(h) Expertise and Experience

More professional knowledge and experience are needed in terms of operational needs, and it needs to be a solution at all levels of the construction industry (Buchli *et al*., 2018).

(i) Lack of Flexibility and Customization Product

In the construction industry, every project is different. Therefore, few people will be sure that the investment in the implementation of robotic systems can be used in future projects with different customers (Delgado *et al*., 2019).

2.5 Methods Improvement Implementation Robotic Technologies

To reduce the challenges, different methods can be implemented and some participants should play their roles in driving this change.

(a) Investment Tax Allowance

The high of the bank's interest rate also is a factor that affects equipment purchases. The government should promote robotic technology users to have loans at a lower interest rate to encourage using robotic technologies (Akinradewo *et al*., 2018).

(b) Incentives by Government Program

Malaysia's government promoted a program to develop robotic technologies in the construction industry also as a way to implement robotic technologies (Yahya *et al*., 2019).

(c) Cooperation with Company

Cooperation among two companies can learn from each other about knowledge of robotic technologies and can help the future development among two companies (Yahya *et al*., 2019).

(d) Funds Rewards

Paying funds incentives to the construction industry to support using robotic technologies and can reduce the funding issues faced by construction employers (Samari *et al*., 2012).

(e) Retraining Workers Program

Additional education and knowledge are important to employees because it not only enables them to better understand robot colleagues but also provides them with opportunities to grow and make greater contributions to the enterprise (Davids, 2017).

(f) Implement Research and Development (R & D) measures

The implementation of R & D in the construction industry will happen when the construction player they found by using these robotic technologies can get the benefit and advance in economics (Mahbub, 2015).

(g) CIDB Development Plan

CIDB established a center of excellence and became a one-stop technology adoption center with a workshop or seminar to increase the adoption of robotic technologies in the construction industry (Yahya *et al*., 2019).

3. Research Methodology

A research methodology describes and analyses methods to better understand and explains its assumptions and research results (Igwenagu, 2016).

3.1 Research Design

In this research, 5 phases of the process consisted to describe the process and procedure activity from the beginning to the end of this research. The first phase is the initial research, in this phase, it studies the topic of research and identifies research background, problem statement, research objective, research question, research scope, and research significance. The second phase is a discussion about literature review. This phase is a study of the literature related to the topic. The third phase is data collection. In this phase that had been divided into two categories which are primary data and secondary data. Primary data use mixed-method to carry out the data in this research. The mixed-method is the combination of quantitative research and qualitative research. Questionnaires and interviews were being done among the G7 construction company to gain the research objective. The next phase is data analysis, data analysis is a step that needs to analyze the data collected through quantitative research and qualitative research. Data collected from qualitative research was be analyzed using thematic analysis. Descriptive analysis (SPSS) also was being used in the analysis of data collected from quantitative research. The last phase is conclusion and recommendation, data has been analyzed from the phase before it will be concluded. The recommendation is also given in this phase to give suggestions for further research.

3.2 Data Collection

In primary data, mixed-method combining quantitative and qualitative research are the method used in this study. To achieve the objective in this study questionnaires and semi-structured interviews were being conducted as a sequence for collecting data. Some related journal articles, books, and magazines, websites have been applied to become secondary data.

3.3 Research Instrument

Research instruments tools used in this study are questionnaires and interviews. Questionnaires were involved 79 respondents to gain objective 1 and objective 2. Google Forms was used for planning and management questionnaires. Four main sections which are sections A, B, C, D were divided into questionnaires in this study. Five respondents were involved in the interview session to gain objective 3. Therefore, to achieve the third objective, a semi-structured interview was interviewed with five G7 Construction companies. Due to pandemic Covid-19, interview form has been using email to collect feedback respondent. Interview questions are established and considered with three sections which are sections A, B, and C.

3.4 Population

The population for this research was only focused on the G7 construction company located in Johor Bahru area because the construction company holds a G7 license approved by the Malaysian Construction Industry Development Board (CIDB) so that they can engage in unlimited civil engineering construction and housing construction projects (Nathan, 2015). According to Official Portal CIDB (2019), there are 693 population size G7 construction companies registered under CIDB located in Johor Bahru. Based on Morgan and Krejcie (1970) table for determining the sample size for a given population over 693, hence sample size of corresponding in questionnaire is 248 using in this research. Hence according to Cresswell (2007), semi structured interviews require a minimum sample size of between 5 and 25. Therefore 5 respondents has selected involve in the semi structured interview.

3.5 Data Analysis Method

Data collected from qualitative research was be analyzed using thematic analysis. Thematic analysis is a foundational technique of research (Braun & Clarke, 2006). Descriptive analysis (SPSS) was to be used in quantitative research. This method can generalize all huge quantities and filter them into simple statistics (William, 2020).

4. Results and Discussion

4.1 Questionnaire Data Results and Discussion

4.1.1 Respondent Background

From the data collected had shown in Table 1 below, 100% of 79 respondents are known about what is MCS. In this research, they are 24.1% had involved in the affordable housing project. This means that 75.9% were didn't experiences involve in the affordable housing project. Male respondents in this research (58.2%) and female respondents (41.8%). The major jobs position of the respondents are Contractor (25.3%), followed by Engineer (24.1%), Project Manager (17.7%), Architect (15.2%), Site Supervisor (10.1%), and the last is Quantity Surveyor (7.6%). The respondent had a participant in this survey are from group 0-5 years of experiences (26.6%). Follow with the respondent who had 6-10 years of experience (25.3%). Whereas (29.1%) of respondents fall into the group 11-15 years of experience. There is 11.4% of respondents with 16-20 years of experience. Last is the respondent in the group for more than 20 years of experience only 7.6%.

Table 1: The Summary of Respondent Background.

Item		Frequency	Percentage(%)
Do you know MCS	Yes	79	100
	No	0	0
Are you involve in affordable housing project	Yes	19	24.1
	No	60	75.9
Gender	Male	46	58.2
	Female	33	41.8
Job position	Contractor	20	25.3
	Architect	12	15.2
	Engineer	19	24.1
	Quantity survey	6	7.6
	Project manager	14	17.7
	Site supervisor	8	10.1
Years of Experiences	0-5 years	21	26.6
	6-10 years	20	25.3
	11-15 years	23	29.1
	16-20 years	9	11.4
	More than 20 years	6	7.6

4.1.2 Understanding Modular Construction System in Affordable Housing.

(a) Definition of MCS

This section is discussed about the knowledge respondent on definition MCS. Table 2 shows the mean and rank had been analyses after collected from 79 respondents this research. From the survey, 82.3% of respondents strongly agree that modular construction system can be known as a modular building system, volumetric construction, and modular system. Besides, 82.3% of respondents strongly agree that modular construction systems are usually stronger than those built on-site. Also, 74.7% of respondents strongly agree that modular can independently withstand the severe tests of transportation and driving on the foundation. Modular construction system refers to the process of designing a building using the same materials under the controlled factory conditions had strongly agreed by 82.3% of respondents. On the other hand, 70.9 % of respondents strongly agree that a modular construction system refers to the process of designing a building using the same codes and standards under controlled factory conditions.

Besides that, 75.9 % of respondents strongly agree that a modular construction system combines traditional building technology with efficient manufacturing technology to deliver building projects faster and smarter. Also, 77.2 % of respondent strongly agree that modular construction system is

fully assembled in manufacturing plants and modular construction system are uses pre-engineered volumetric units that are fitted-out and called as 'building blocks' will be installed on-site. Last, definition modular construction system involves prefabricated modules or units are manufactured in workshop or factory according to specifications and then installed on-site and modular construction system is a modular transported to the construction site to install to a building, this new approach permits the reduction construction period. Both of them had 82.3% of respondents strongly agree. Findings related to frequency is shown in Table 3 below.

Table 2: Mean Score and Rank on Definition of MCS

Definition	Mean	Rank
(i) MCS also can be known as a modular building system, volumetric construction, and modular system.	4.82	1
(ii) MCS are usually stronger than those built on-site.	4.75	4
(iii) A module can independently withstand the severe tests of transportation and driving on the foundation.	4.70	8
(iv) MCS refers to the process of designing a building using the same materials under controlled factory conditions.	4.77	3
(v) MCS refers to the process of designing a building using the same codes and standards under controlled factory conditions.	4.65	10
(vi) MCS combines traditional building technology with efficient manufacturing technology to deliver building projects faster and smarter.	4.73	5
(vii) MCS fully assembled in manufacturing plants.	4.68	9
(viii) MCS uses pre-engineered volumetric units that are fitted out and called 'building blocks' will be installed on-site.	4.73	6
(ix) Modular transported to the construction site to install to a building, this new approach permits the reduction construction period.	4.80	2
(x) Prefabricated modules or units are manufactured in a workshop or factory according to specifications and then installed on-site.	4.70	7

Table 3: Frequency on Definition of Modular Construction System.

Definition	SD	D	N	A	SA	Total	Mean	Rank
MCS also can be known as modular building system, volumetric construction and modular system.	0 0.0%	0 0.0%	0 0.0%	14 17.7%	65 82.3%	79 100%	4.82	1
MCS are usually stronger than those built on site.	0 0.0%	1 1.3%	3 3.8%	11 13.9%	64 81.0%	79 100%	4.75	4
Module can independently withstand the severe tests of transportation and driving on the foundation.	0 0.0%	0 0.0%	4 5.1%	16 20.3%	59 74.7%	79 100%	4.70	8
MCS refers to the process of designing a building using the same materials under the controlled factory conditions.	0 0.0%	0 0.0%	4 5.1%	10 12.7%	65 82.3%	79 100%	4.77	3

MCS refers to the process of designing a building using the same codes and standards under the controlled factory conditions.	0	0	5	18	56	79	4.65	10
	0.0%	0.0%	6.3%	22.8%	70.9%	100%		
MCS combines traditional building technology with efficient manufacturing technology to deliver building projects faster and smarter.	0	0	2	17	60	79	4.73	5
	0.0%	0.0%	2.5%	21.5%	75.9%	100%		
MCS fully assembled in manufacturing plants.	0	1	5	12	61	79	4.68	9
	0.0%	1.3%	6.3%	15.2%	77.2%	100%		
MCS uses pre-engineered volumetric units are fitted out and called as 'building blocks' will be install on site.	0	0	3	15	61	79	4.73	6
	0.0%	0.0%	3.8%	19.0%	77.2%	100%		
Modular transported to the construction site to install to a building, this new approach permits the reduction construction period.	0	0	2	12	65	79	4.80	2
	0.0%	0.0%	2.5%	15.2%	82.3%	100%		
Prefabricated modules or units are manufactured in workshop or factory according to specifications and then installed on site.	0	0	2	20	57	79	4.70	7
	0.0%	0.0%	2.5%	25.3%	72.2%	100%		

From the data had been analyzed, it can conclude that most of the respondent agree that Modular Construction System would use various word phrases to present it. It is also a method that can be transported to the construction site and assembled at the site, this process is the latest way to minimize the project time in the construction industry. This is supported by Musa *et al*. (2016) MCS also can be known as a modular building system, volumetric construction, and modular system. After the modular unit is completely renovated, it will transport to the site and stacked on the prepared foundation to form a building. On the other hand, most of the respondents agree that it is a system, unlike the traditional construction method which is a method that combines traditional building technology. Pre-engineered volumetric units are fitted out according to specification, and the "building blocks" will install on-site. This system can help project schedules to become faster and smarter. This is supported by Samsung C&T (2016) and Modular Building Industry Association Australia (MBIAA) (2019). Modular construction unlike traditional construction methods, modular construction starts from a different place. In a controlled workshop or factory, prefabricated modules or units are manufactured according to specifications to installed on-site, and modular building are combines traditional building technology with highly controlled and efficient manufacturing technology to deliver building projects to customers faster and smarter respectively.

(b) Characteristics of MCS

This section is discussed about the knowledge of the respondent on characteristics MCS. Table 4 below shows the mean and rank had been analysis after collected from 79 respondents in this research. There were 3 types of characteristics has found in this research. Easy to disassembled and reusable construction method has got the highest rank with 4.76 means. Other than that, over 80%of respondents which are 81% they strongly agree with reducing excess materials can ultimately reduce waste from modular construction. Recyclable modules can ultimately reduce waste from modular construction and most parts of the modular unit can be constructed with recyclable materials, such as recycled steel, wood, and even glass. Both of this has been strongly agreed by 78.50% of respondent.

The sustainable method gets the mean of 4.67 and is the last cumulative rank. In this characteristic, 79.7% of respondents strongly agree that modular structure can greatly reduce the demand for raw materials and energy. Also, 72.2% of respondents strongly agree that most MCS buildings are completed indoors, there is less risk of environmental hazards. Besides that, 82.30% of respondents strongly agree MCS can reduce the impact on the site environment since most construction is done offsite.

Increase schedule gets the mean 4.74 and is placed second cumulative rank. 72.2% of respondents strongly agree when modular units produce offsite, work at site preparation also can be done simultaneously. Same of the percentage respondent which is 77.20% strongly agree MCS can completing work at the same time can reduce project time by up to half of traditional construction time. Also, 82.3% of respondents strongly agree about MCS construction processes are completed inside the factory, which can greatly reduce the delay. Table 5 below shows the frequency of characteristic of MCS.

Table 4: Mean Score and Rank on Characteristics of MCS

Characteristic	Mean	Rank	Cumulative Rank
Sustainable method	4.67		3
1. The modular structure can greatly reduce the demand for raw materials and energy.	4.68	7	2
2. In MCS most buildings are completed indoors, there is less risk of environmental hazards.	4.56	9	3
3. Reduce the impact on the site environment since most construction is done offsite	4.56	2	1
Increase Schedule	4.74		2
1. When modular units produce offsite, work at site preparation also can be done simultaneously.	4.67	8	3
2. Completing work at the same time can reduce project time by up to half of traditional construction time.	4.72	6	2
3. Most MCS construction processes are completed inside the factory, which can greatly reduce the delay.	4.82	1	1
Easy to the disassembled and reusable construction method	4.76		1
1. Most parts of the modular unit can be constructed with recyclable materials, such as recycled steel, wood, and even glass.	4.75	5	3
2. Reducing excess materials can ultimately reduce waste from modular construction.	4.77	3	1
3. Recyclable modules can ultimately reduce waste from modular construction.	4.77	4	2

Table 5: Frequency on Characteristic of Modular Construction System (MCS).

Characteristic	SD	D	N	A	SA	Total	Mean	Rank	Cumulative Rank
Sustainable method							4.67		3
Modular structure can greatly reduce the demand for raw materials and energy.	1	3	0	12	63	79	4.68	7	2
	1.3 %	3.8 %	0.0 %	15. 2%	79.7 %	100%			
In MCS most buildings are completed indoors, there is less risk of environmental hazards.	1	2	6	13	57	79	4.56	9	3
	1.3 %	2.5 %	7.6 %	16. 5%	72.2 %	100%			
Reduce the impact on the site environment since most construction is done offsite	0	1	2	11	65	79	4.77	2	1
	0.0 %	1.3 %	2.5 %	13. 9%	82.3 %	100%			
Increase Schedule							4.74		2
When modular unit produce offsite, work at site preparation also can be done simultaneously.	0	1	6	11	61	79	4.67	8	3
	0.0 %	1.3 %	7.6 %	13. 9%	77.2 %	100%			
Completing work at the same time can reduce project time by up to half of traditional construction time.	0	0	4	14	61	79	4.72	6	2
	0.0 %	0.0 %	5.1 %	17. 7%	77.2 %	100%			
Most MCS construction processes are completed inside the factory, which can greatly reduce the delay.	0	0	0	14	65	79	4.82	1	1
	0.0 %	0.0 %	0.0 %	17. 7%	82.3 %	100%			
Easy to disassembled and reusable construction method							4.76		1
Most parts of the modular unit can be constructed with recyclable materials, such as recycled steel, wood and even glass.	0	1	1	15	62	79	4.75	5	3
	0.0 %	1.3 %	1.3 %	19. 0%	78.5 %	100%			

Reducing excess materials can ultimately reduce waste from modular construction.	0 0.0 %	0 0.0 %	3 3.8 %	12 15. 2%	64 81.0 %	79 100%	4.77	3	1
Recyclable modules can ultimately reduce waste from modular construction.	0	0	1	16	6	79	4.77	4	2

The common characteristics of MCS can be concluded as a sustainable method, increase schedule, and easy to disassembled and reusable construction method. Most of the respondents agree that the characteristics of MCS are sustainable methods. MCS is a structure that can be characterized as off-site construction, and by reducing demand for raw materials and energy, this can ensure that the site environment is clean and good. This statement can be supported by Robinson (2019). The modular structure can greatly reduce the demand for raw materials and energy. Reducing excess material and being able to recycle modules can reduce waste. Since most construction is done on-site, you can also reduce the impact on the site environment. Good planning also can reduce the number of vehicles and equipment needed on the construction site.

Moreover, the respondents also agree that increase the project schedule also is characteristic of MCS. Work on-site planning may also be performed together while the modular units are built inside the factory when a project uses MCS. In comparison with the traditional approach, this method will minimize up to half the time. This can be proved by Musa *et al*. (2016) when the modular unit produces, work at site preparation also can be done simultaneously. so in this process, it can shorten the time using in a project. Modules build in the factory and perform both on-site and basic work. Completing work at the same time can reduce project time by up to half of traditional construction time.

The last characteristic also gets consent from the respondent which is MCS is a method that can be easily disassembled and reusable. Through reducing and restoring modular construction components, most parts of the modular unit can be built from recyclable materials such as recycled steel, wood, and even glass, which can eventually minimize waste in the construction industry. This statement is similar to Wong's (2018) study. Besides, most parts of the modular unit can be constructed with recycled or recyclable materials. Reducing excess materials and recyclable modules can ultimately reduce waste from modular construction.

4.1.3 Challenges of Modular Construction System (MCS) to applying robotic technology in Malaysia affordable housing industry.

Table 6 shows the challenges faced by MCS in the application of robotics in the affordable housing industry in Malaysia. Rank used to indicate a challenge with a high impact (such as number 1) and a challenge with a small impact (such as 9).

Table 6: Mean Score and Rank for the Challenges of Applying Robotic Technology

Challenges	Mean	Rank
Cost	4.60	1
Neoteric method	4.39	2
Employee Employment Opportunities	4.26	7
Lack of investment in R&D	4.31	3
Investor Resource	4.18	8
Re-training of worker	4.31	4

Lack of space	3.80	9
Expertise and Experience	4.26	6
Lack of Flexibility and Customization Product	4.28	5

Most of the respondents agree that cost is the biggest challenge in MCS to applying robotic technology. Cost becomes the first barrier because a lot of costs have to be spent on maintenance when implementing new technology in a business, employing special professional technicians to upgrade and refresh the technology. This can be supported by Akinradewo *et al*. (2018). To implementation robotic technologies, high expense cost, and expensive cost of the maintenance machinery needed to afford. To improving and satisfy a need for task performance, the expensive cost will be payable on using robotic technologies.

On the other hand, respondents believe that the neoteric method is a challenge in MCS to applying robotic technology. Most of the workers in the Malaysian construction sector are international and have not obtained higher education. This led managers to worry if employees are capable of adopting new technologies. This can be supported by Akinradewo *et al*. (2018) most construction workers have received training in the same industry and happened to specialize in the industry for many years, which makes it difficult for workers to consider training because it requires a little academic background.

Hence from the finding in Table 4.4, most of the respondents agree to the lack of investment in R&D also is a challenge in MCS. R&D is a component of a successful business. Many companies in the business do not invest in R&D and would not attract the opportunities of independent innovation to the contractors. This can be supported by Shekar & Kumaran (2018). Research and development (R&D) are one of the success factors of a business but many companies ignore the importance of R & D.

Additionally, re-training worker is the next challenge agree by the respondent in applying robotic technology. To ensure that they interact with new robotic equipment and ensure their safety, trained operators need to train staff who will operate robotic technology. This can be supported by Davids (2017) employees will worry about turning to automation so they will need to understand how these new robots work and the proper functions to ensure their safety.

Employee employment opportunities are the next challenge. The respondent agrees with this challenge, as the construction industry in Malaysia is one of the industries with the most job opportunities. Workers affected will be forced to adjust the structure of jobs and will use robotics and automation to replace labor effects. This is support by James *et al*. (2006). Using robotic technologies in the construction industry can reduce and save labor costs at the same time can increase productivity, and substitute labor will happen.

From finding there was a challenge getting lower rank supported by the respondent which is investor resources and space problem on site. Small companies have not marketed themselves to the market and have impacted the prospects for investment. This condition allows a stronger organization to have a better chance of implementing or acquiring robotic technology with a small business. This is support by Kamar & Hamid (2009). Between the small company and the bigger company, stronger company have a higher chance to adopt or buying robotic technologies, this cause the small company hasn't promote themselves into the market difficult to apply this technology. Due to the space problem challenge, a suitable site needs to use for the application of the technology to ensure the safety of the worker early mowing something on site. This was supported by Heiskanen, (2014). Keep the workplace tidy and ensure the environment of the site is safe and prefer using.

4.2 Interview Data Results and Discussion

4.2.1 Respondent Background

Five respondents had been a participant in this research. Table 7 below shows the respondent's background about gender, job position, and years of working experience.

Table 7: The Summary of Respondent Background

Gender	Respondent	Job Position	Years of Experience
Male	Respondent 1	Project Manager	10 years
Male	Respondent 2	Contractor	6 years
Male	Respondent 3	M&E Engineer	6 years
Male	Respondent 4	Principal Engineer (civil)	33 years
Female	Respondent 5	Project Manager	16 years

4.2.2 Method Improvement Implementation of Robotic Technology in Modular Construction Systems (MCS)

Table 8 shows the method that can improve using robotic technology in MCS. It can conclude that most of the respondents agree that the method which is investment tax allowance, cooperation with high technologies company, incentives by the government program, paying funds incentives by government, retraining workers program, CIDB development plan and implement research and development (R & D).

Table 8: Method for Improvement

Interview Findings (Method for Improvement)	Respondent				
	R1	R2	R3	R4	R5
Investment tax allowance	/	/	/	/	/
Cooperation with high technologies company	/	/	/	/	/
Incentives by the government program	/	/	/	/	/
Paying funds incentives by the government	/	/	/	/	/
Retraining workers program	/	/	/	/	/
Implement research and development (R & D)	/	/	/	/	/
CIDB development plan	/	/	/	/	/

Notes: (/) Agree

From the finding, it is shown that most of the respondent they agree investment tax allowance can be used to reduce tax profit and reduce the company finance cost to encourage investment from manufacturing company application robotic technologies as what mentioned by Respondent 1 and 5. This is supported by Akinradewo *et al*. (2018) promote the investment tax allowance to the company that application robotic technologies will help them to reduce the finance costs. Moreover, respondents also agree that the next method is cooperation with High Technologies Company. Through this method, the construction company can learn and understand more about using robotic technology by sharing the experience with the high tech construction company as mention by respondent 5. This is supported by Yahya *et al*. (2019) cooperation among two companies can learn from each other about knowledge of robotic technologies and can help the future development among two companies.

The next method that can be improved the implementation of robotic technology in MCS are incentives by the government program also agree by the respondent. This incentive will help the companies increase the efficiency of their work as all the workers knew how to use the robotic

technologies and the application of robotic technologic in MCS as mention by respondent 3. Paying funds incentive also is a method to support using robotic technologies in MCS. Funds incentive by the government can be used by the company to solve their problems in cost and fund issues when application robotic technology as what mention by respondent 1 and 5 is similar with Samari *et al*. (2012) study through ways of paying funds incentives to the construction industry to support using robotic technologies and can reduce the funding issues faced by construction employers. Other methods can be found from the interview the respondent are retraining workers program. Retraining workers very important when a company they needed to using or applying a new method. By retraining workers, they can gain knowledge on how to control and handle robotic technology. When workers perform in using robotic technologies, they can give good feedback to the company to applying robotic technology as mention by respondent 1 and 4. This is supported by Davids (2017) additional education and knowledge are important to employees because it not only enables them to better understand robot colleagues but also provides them with opportunities to grow and make greater contributions to the enterprise.

Last but not least, respondents agree to implement research and development (R&D) can be using to improvement are implement research and development (R&D). Using R&D will help a company to make a decision can afford it or not and help a company more understand about the benefit will come to a company when using robotic technology as what mentioned by respondent 2 similar with the Mahbub (2008) study. The implementation of R&D in the construction industry will happen when the construction player they found by using these robotic technologies can get the benefit and advance in the economy. The last method is by using the CIDB development plan. CIDB development plan provides the information expert guidance and facilitates new standards to the construction player about the application robotic technologic in MCS. However, CIDB development plan can provide subsidies, program, and knowledge to industry players using of robotic technologies in MCS to encourage the construction company using robotic technology as what mention by respondent 1, 3, and 5. This is supported by Yahya *et al*. (2019) CIDB establish a center of excellence and become a one-stop technology adoption center by providing seminars or workshops to increase the adoption of robotic technologies in the construction industry.

4.2.3 Personal perspective Respondent

This section discussed findings related a personal perspective on how the method can improve the implementation of robotic technology in MCS as shown in Table 9. Respondents 1, 3, and 4 giving the same feedback which is a strategic partnership with high technologies companies can be the method improvement. While Respondent 2, and 5 feedback by doing research, testing and finding and motivation camp respectively.

Table 9: Personal Perspective of Respondent

Respondent's Personal Perspective	R1	R2	R3	R4	R5
Strategic partnership with high technologies companies	/	X	/	/	X
Motivation Camp	X	X	X	X	/
Do research, testing and finding	X	/	X	X	X

Notes: (/) Agree, (X) Disagree

Data personal perspective on how the method can improve the implementation of robotic technology in MCS collect form respondent. It can be concluded that the method of making a partnership with a company overseas or local company having experience in MCS. By partnership, they can share, learn and discuss together related to MCS.

5. Conclusion

The results of this study were analysis and identify. For the knowledge about the G7 Construction company, from the feedback, it can define that most of the respondents also know MCS. In the application of robotic technologies in MCS for affordable housing in the Malaysia Construction

Industry, some of the challenges need to be faced by the construction player. From the data collection, it can be concluded that the cost factor is the top challenge faced when application robotic technology. Some incentive methods can be used in the Malaysia construction industry to applying robotic technology in MCS also has been finding in this research. The data obtained by the researcher is only from view G7 construction player located in Johor Bahru. Therefore, it is recommended the future researcher can research about acceptable by Malaysia housing buyers of using Modular Construction systems in the construction industry. Due to the project of MCS is still less, so the future researcher also can identify the completed project that had using Modular Construction System in Malaysia and the impact of Modular Construction System to Malaysia construction industry.

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