PERCEPTION TOWARDS COST IMPLICATION OF MECHANISATION AND AUTOMATION APPROACH IN IBS PROJECTS IN MALAYSIA

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Industrialised Building System (IBS) is defined as a construction technique which components are manufactured in a controlled environment (on or off site). These components are then transported, positioned and installed into a structure without too much site works performed by labours. The agenda of IBS has been duly highlighted in the Malaysian Construction Industry Master Plan (2005-2015) as being of significant importance to the Malaysian construction industry. The Malaysian government is also committed not only in addressing the IBS agenda but also meeting its target and adopting innovations in the near future. The aim of the main research is to investigate the cost implication factors of mechanisation and automation approach in IBS projects. The methodologies are based on a thorough literature review, quantitative and qualitative method using semi structured interviews which were conducted among IBS manufacturers, developers and contractors in Malaysia. Capital cost, maintenance cost, operation cost, inadequacy of market size, site arrangement, upgrading, availability of machine locally, site location, training and transportation are among the major cost factors highlighted by the IBS players. These cost factors require considerable attention when the mechanisation and automation approach are to be fully implemented in IBS projects in Malaysia. The findings on the cost implication of the mechanisation and automation approach in IBS will be able to guide the industry players and the government in their quest to reduce the country's over-dependency on foreign workers by encouraging the use of labour saving devices at an optimum cost. Subsequently, the IBS needs mechanisation and automation approach to push their agenda forward to meet the government's transformation policy towards modernising the construction industry in line with other developed countries by the year 2020.

Keywords: costs, industrialised building system , mechanisation, automation.

INTRODUCTION

Malaysia is a dynamic country which is constantly evolving. Being a middle-income country, Malaysia has transformed itself since the 1970s from a producer of raw materials into an emerging multi-sector economy spurred on by high technology, knowledge-based and capital intensive industries. In Malaysia, the government is aware of the importance of developing a capable construction industry driven by technological development in the manufacturing and service industry that can contribute to the economy Azman et al. (2010). In 2008, a circular from the Malaysian Treasury Department, Ministry of Finance denotes full utilisation of IBS for all

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government projects in Malaysia whereby the use of IBS components in government projects must not be less than 70% (Kamar et al. 2009). This is because the IBS has the compensation factors of speed, safety and quality and Malaysia is in a dire need of fast and high quality products for the local construction industry as well as able to complete with the global market. Dealing with the issue on the influx of foreign labour, to stop illegal workers abruptly can be very costly, time consuming and involved a large number of enforcement personnel. The government may need to work hard with the industry to study ways to reduce the country's dependence on foreign workers by encouraging more labour saving devices such as construction methods using IBS and through greater mechanisation and automation approach. Mechanisation and IBS are interrelated to each other. IBS needs mechanisation to fulfil its cycle till the complete erection of those IBS components on site. The automotive industry has moved from craft-based production to mass production and yet people still talk of moving the construction industry from a craft-based to a manufacturing industry (Crowley, 1998). This statement was supported by Azman et al. (2010) in the context of the Malaysian construction industry which is currently in the process of being transformed into a mass manufacturing and production industry in view of developing standardisation of products in line with the demanding local and global markets.

Therefore, the main research aims to investigate the cost implication factors of mechanisation and automation approach in IBS project. However, this paper will attempt to complement precedent studies whilst contributing to IBS research in guiding the industry players and helping the Malaysian government in their quest to reduce the number of foreign workers.

LITERATURE REVIEW

Industrialised Building System (IBS) and the Malaysian Construction Industry

The use of IBS has turned the Malaysian housing industry into one of the mass producers of houses per capita basis than any other countries in the world. It can be defined as an approach or process used in making construction less labour oriented and faster and fulfilling quality concerns (Shaari et al. 2003). The broader view of the IBS is about changing the conventional mind-set, championing human capital development, developing better cooperation and trust, and promoting transparency and integrity (Shaari et al. 2003). The term was invented to shift from the typical paradigm of prefabricated systems. According to the Malaysian Construction Industry Development Board (CIDB) IBS Digest Bulletin Issue 02 2010, IBS is defined as a construction process that utilises components or building systems which involve prefabricated components and on-site installation. From the structural classification, they are divided into six main IBS groups or categories that are popularly used in Malaysia which includes: precast concrete framing; panel and box systems; formwork systems; steel framing systems; prefabricated timber framing systems; and block work systems. Azman et al. (2010) has come up with the table of categorisation of IBS components in the context of Malaysian construction industry as in Table 1.

The term used for IBS may be different from one country and another. Azman et al. (2010) has found out that the term used in the UK is known as the Modern Methods of Construction (MMC) or Off-site Manufacturing. MMC is the term used by UK government to describe a number of innovations in house building, most of which are offsite technologies, moving work from the construction site to the factory. On the other hand, in Australia, the IBS is better known as the Off-Site Manufacture (OSM).

The OSM term has been well known in Australia and internationally as in UK, US, and European countries as well.

Table 1: Categorisation of IBS Components in Malaysia

IBS Introduce in	Categorisation of IBS	IBS Components
Early 60's	Badir et al. (2002)	Frame System
		Panel System
		Box System
Early 90's	Badir and Razali (1998)	Precast concrete framing, panel and box systems
		Load bearing block
		Sandwich panel
		Steel frame
2003	CIDB (2003)	Pre-cast concrete framing, panel and box systems
		Formworks systems
		Steel framing systems
		Prefabricated timber framing systems
		Block work systems
2010	CIDB (2010)	Pre-cast concrete systems
		Formworks systems
		Steel framing systems
		Prefabricated timber framing systems
		Block work systems
		Innovative

The IBS offer benefits to adopters that concerned about cost and time certainty, attaining better construction quality and productivity, reducing risk related to occupational safety and health, alleviating issues skilled workers and dependency on manual foreign labour, and achieving the ultimate goal of reducing the overall cost of construction (Lou et al. 2012). As of February 2009, 320 government projects worth RM9.43 billion have been carried out using the IBS construction approach. The government has also realised that it is also important for the private sector to participate aggressively in the IBS construction approach. Currently there is an exemption in the form of tax levy (0.125% of project cost) for contractors who are using a minimum of 50% of the IBS score in the construction of residential buildings.

According to Hamid et al. (2011) in Finland, IBS (or offsite manufacturing as it is better known in the European Union) represented 70% of total building construction. It offers effective and rapid site assembly and improving the quality and productivity of construction. Japanese house building industry has developed the most advanced manufacturing techniques in construction. Automation and robotics are applied in both manufacturing techniques in construction. Meanwhile, Hamid et al. (2011) adds that offsite manufacturing in German house building industry has improved quality and provided a better value with considerable variety and flexibility in design. It has also helped the developers to overcome strict standard of quality control imposed by local authorities.

According to Thanoon et al. (2003) in the early 60s, the IBS method has been adopted due to the need of accomplishing large quantities of apartments as quickly as possible by The Housing and Development Board (HDB) of Singapore. Furthermore, in Thailand the usage of Precast Large Panel Construction (PLPC) as an example of IBS components has been widely used in Thailand as the government of Thailand planned to build about 600,000 housing units for the low to medium income level population within three years starting the year of 2004 (Thanoon et al. 2003). Meanwhile, Thanoon et al. (2003) the organisation of The Building America Industrialised Housing Partnership (BAIHP), IBS is gaining fast popularity in the USA market in term of both high rise and low rise buildings. According to the researcher Thanoon et al. (2003), the experiences in some developed countries such as United Kingdom and Japan indicate that there is a great potential for IBS to progress as it offers loads of benefits towards the civilization both economically and socially. IBS has already been successfully adopted in Finland, Japan, UK, USA and Singapore where technologies had eventually modernised and improved the industry. However, in Malaysia, according to Kamar, (2009) the percentage of IBS usage is still considered low and deteriorating. This indicates that to be successful, the Malaysian construction industry shall not work in isolation but to benchmark and learn from others.

Therefore, the latest IBS Roadmap from 2011 to 2015 has stated that among the objective is to impose a high-level intended outcome when implementing IBS. The four policies include good on quality, design, components and finished buildings. Aesthetics should be promoted through innovation to ensure that by using IBS the completion time of a building is not only speedier but more predictable and well-managed (Kamar et al. 2012). Concurrently, there is a need to have a ready pool of competent IBS professionals and workers throughout the entire project life-cycle; from design, manufacture, and construction up to maintenance to create a financially sustainable IBS industry that balances users need and affordability as well as manufacturers viability. Apart from this, IBS offers minimal wastage, fewer site materials, a cleaner and neater environment, controlled quality, and lower total construction costs (Pan et al. 2008, Hamid et al. 2008 and Pan et al. 2007).

Mechanisation and Automation in Construction Industry

There are five degrees of industrialisation described by Richard (2005). They are prefabrication, mechanisation, automation, robotic and reproduction (Figure 1). Prefabrication is a manufacturing process that takes place at a specialised facility, in which various materials joined to form a component part of the final installation. Mechanisation comes in whenever machinery employed to ease the workload of the labourer. Automation is a situation when the tooling (machine) completely takes over the tasks performed by the labourer. Robotics comprises the ability of the same tooling which has the multi-axis flexibility to perform diversified tasks by itself. This allows the mass- customisation concept. Reproduction implies that the research and development of innovative processes is truly capable of simplifying the production process. According to Richard, (2005) the first four degrees are still more under the influence of the traditional methods of building. Prefabrication aims rather at the location of the production where the next three degrees (mechanisation, automation and robotics) aim at substituting labour with machineries (Richard, 2005). This range of this research is in between the mechanisation a bit into the earlier stage of automation implementation on site.

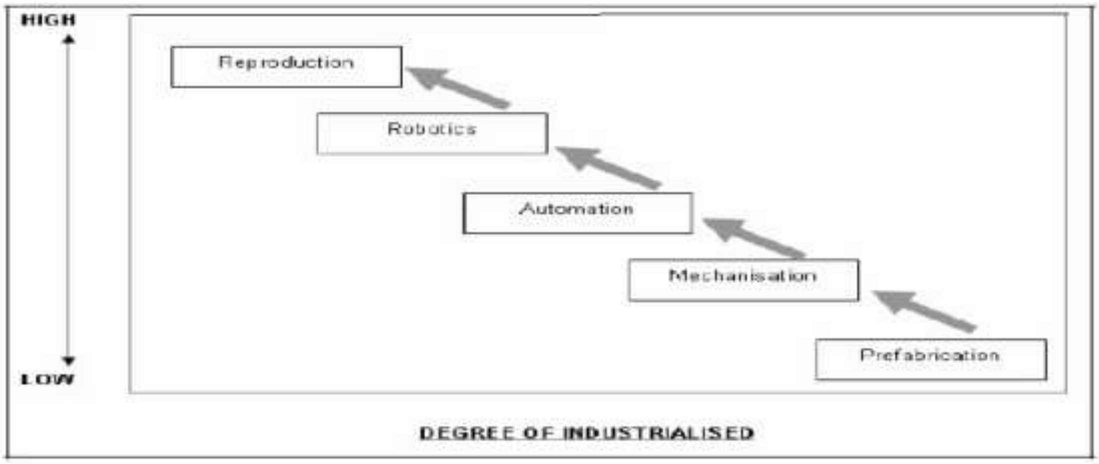

Figure 1: Degree of industrialisation (Richard, 2005)

Mahbub (2012) highlighted that the problems associated with the construction industry such as decreasing quality and productivity, labour shortages, occupational safety and inferior working condition have highlighted the need for an innovative solution within the industry, including the push for further use of industrialisation and construction automation and robotics application on site.

Mechanisation can be described as the process of applying the use of mechanical plants in carrying out a task. The level of mechanisation defined as the number of plants and equipment employed or the number of activities carried out by mechanical plants in an operation (Idoro, 2008).

According to Parker (1989) and Navon (1996) automation is defined as “the replacement of human, labour by machines; or the operation of a machine or device automatically, or remote control”. Richard (2005) stated that automation is the tool that is completely taking over the tasks performed by the labour although the “supervisor” is still around. Other than that according to Slaughter (1997) “automated” devices may include other manipulators and equipment that follow a fixed sequence or remote controls.

The Cost Factors on Mechanisation and Automation in IBS Construction Project

Mahbub (2012) have set up the barriers in the implementation of automation and robotic in construction which include high in cost, financial commitments in acquiring and maintaining the technologies. Navon (1996) has listed down that economic analysis is one of the factors that need to be considered in teaching automation as part of the construction curriculum. Results from his survey have shown that the automation system would be economical if it could replace at least one worker. Navon (1996) has also listed ten parameters of the automation system economic analysis which is the initial investment cost, economic life, interest rate, repair and maintenance, operating cost, transfer cost, number of saved workers, labour cost, robot employment time and tax reduction. Warszawski (1985) had come out with an economic feasibility study of robot employment in construction tasks which encompassed development cost: include all expenses associated with labour, materials and facilities used for researching, testing and evaluating of the various alternatives of robotics solutions investment costs: include depreciation and interest on investment. The parameters are the cost of new equipment, it is economic life, the salvage value at disposal and the interest charged on investment. Set up costs: include the installation of the equipment at its work place, the running-in, learning and programming expenses. Maintenance costs: include the regular upkeep, the inspection and repairs of breakdown. Operation costs: include the electricity consumed for robotic work. CIDB (2012) has also listed down several recommendations to encourage the use of mechanisation and automation in construction. Amongst them are: expanding the machinery for the construction manufacturing industry, developing capacity and capability, strengthening research, development and commercialisation, reduction of construction levy for the contractors, a leasing model for buying the machines, financial assistant and tax exemption from the government, and reduction on import duty and sales tax on heavy machineries.

METHODOLOGY

This paper discusses the questionnaire and semi structured interviews conducted with IBS manufacturers, developers and contractors as a part of an on-going research progress on the implementation of mechanisation and automation in IBS projects in Malaysia. Literature review was the first phase of the research. Secondary data were derived from relevant books, journal articles, theses and dissertations, conference proceedings, and reports. This includes the investigation on the cost implication of mechanisation and automation approach in IBS projects in Malaysia with a variety of IBS key players (manufacturers, developer, and contractors). Therefore, the data presented in this paper are only a portion of those collected, and the conclusions presented here are based on interim findings.

The 5-point scale is used to measure responses on the questionnaires. Items are scored on the following keys: 1- No influence at all, 2- Minor Influence, 3- Moderately Influence, 4- Major Influence and 5- Totally Influence. The data gathered through these questionnaires is compiled and fed into the computer to be analysed. The semi structured interviews were conducted in an open ended manner and recorded using digital voice recorder upon obtaining permission from the participants. The recordings were then transcribed for the purpose of data analysis. Answers from interviewees were compared to previous studies' findings were the condition and types of mechanisation and automation are also taken into consideration during the qualitative analysis.

FINDINGS AND DISCUSSIONS

A total of 24 out of 40 respondents returned the questionnaire within three weeks after being sent out. These represent 60% of total respond to rate which is considered to be quite adequate for analysis. Table 2 and Chart 1 explain the job category of the respondents by percentage. Contractors form the highest number of respondents with 11 respondents (45.8%), followed by developers 9 (37.5%) while the manufacturers 4 (16.7%) form the minority population in this study. The survey data is analyses using IBM SPSS Version 20.

Table 2: Job categories of respondents

	Job Category			
	Frequency	Percent (%)	Valid Percent	Cumulative Percent (%)
Contractors	11	45.8	45.8	45.8
Developers	9	37.5	37.5	83.3
Manufacturers	4	16.7	16.7	100.0
Total	24	100.0	100.0	

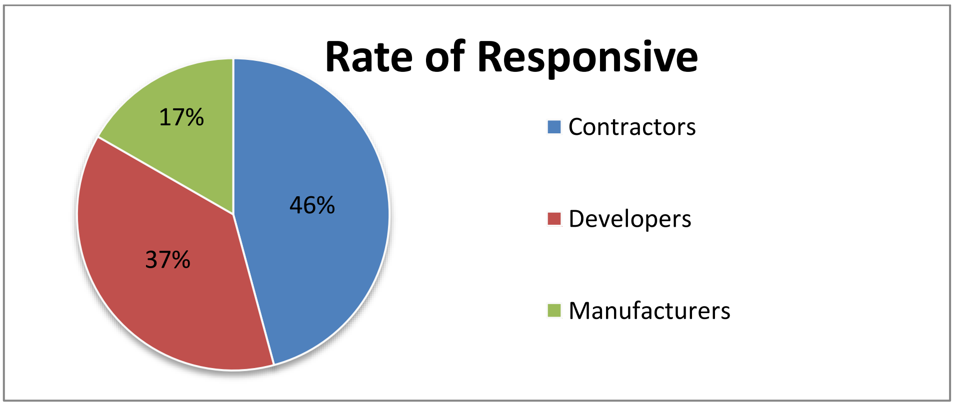

Chart 1: Rate of Responsive

Most of the respondents have good experiences in the industry and IBS construction. According to Table 3, 10 respondents have less than 10 years of experience form the highest percentage (41.7%), 8 (33.3%) of the respondents have experiences between 5 to 10 years and, 6 (25%) of the respondents had 10 years or more experience. Thus, a total of 58.3% of the respondents have been involved in the construction industry for 5 years or more. This represents respondents who had sufficient knowledge on the implementation of mechanisation and automation in IBS. Therefore, the data collected are considered to be reliable and good for an opinion based survey.

Table 3: Respondents experience

	Experience			
	Frequency	Percent (%)	Valid Percent	Cumulative Percent (%)
Less than 5 years	10	41.7	41.7	41.7
5 to 10 years	8	33.3	33.3	75.0
More than 10 years	6	25.0	25.0	100.0
Total	24	100.0	100.0	

Table 4, has shown that the respondents' working experience is sufficient, therefore the results for the Mean, Median and Mode of the data is quite close to each other.

Table 4: Mean, median mode for the working experience

DESCRIPTION		WORKING EXPERIENCE
N	Valid	24
	Missing	0
Mean		1.8333
Median		2.0000
Mode		1.00
Std. Deviation		.81650
Variance		.667
Range		2.00
Minimum		1.00
Maximum		3.00
Percentiles	25	1.0000
	50	2.0000
	75	2.7500

Table 5 illustrates the variables that are rank based on the most influencing factors on the use of mechanisation and automation. It shows that the capital cost is the major factor influencing the cost of mechanisation and automation and that the purchase of plants and machineries will increase the capital cost. This is followed by the maintenance cost, operation cost, and inadequacy of market size, site arrangement, upgrading cost of machines, availability of machine locally, site location, training cost and transportation cost. This finding is in lieu with Navon (1996) and Warszawski (1985) who stated that among the cost of mechanisation and automation are the investment cost, repair and maintenance cost, operating cost as well as labour cost.

Table 5: Factors influencing the mechanisation and automation costs

Item	Description	Rank	Mean
1	Capital cost	1	4.3333
2	Maintenance cost	2	4.2083
3	Operation cost	3	4.0000
4	Inadequacy of market size	4	3.7917
5	Site arrangement	5	3.7500
6	Upgrading cost	6	3.6667
7	Availability of machine locally	7	3.5000
8	Site location	8	3.5000
9	Training cost	9	3.3333
10	Transportation cost	10	3.3333

A combination of literature review and analysis of results was used to arrive at the findings. Based on the results of the interviews, the perceived cost implication factors of mechanisation and automation approach in IBS projects in Malaysia are presented below.

IBS Manufacturers' perception

The mechanisation and automation costs can be very high. The machines can reach up to 1 Million Ringgit Malaysia to 2 Million Ringgit Malaysia per purchase. That is only the initial cost. The machines are all imported because there is no other local technology as yet that can compete with the quality of the imported machines. Even in China, the industry has yet to produce the machineries for construction. Other than that, the wear and tear of the machine components are another aspect that needs to be looked into in the operating cost. All the components such as screws have their time limit whereby when it reaches a certain number of production cycles they need to be replaced. Capital cost will include such thing as purchasing the plants and machineries. Otherwise, the output quality will be affected, and all the components need to be imported from its original manufacturer. The operational and the maintenance cost must also be taken care. Other costs involved are the cost for training or labour cost to train local to use the machines. At the beginning, we had to employ an engineer from Finland to be in charge to train our workers to operate the machines.

Developers' perception

Among the costs that are involved in the mechanisation and automation of IBS are the capital cost to include the purchase of plants and machineries, cost of operation, maintenance cost, training cost for labour and spare parts cost which are machine wear and tear.

Contractors' perception

The contractor usually rent the machines. They have to provide the cost for running the machine which is the operational cost and machines renting cost. Contractor did not need to provide the machine initial cost and maintenance cost because it is covered with the machines provider.

CONCLUSIONS

All three interviewees in this study were asked about their perception on the cost implication of mechanisation and automation in IBS projects in Malaysia. However, their understanding on the cost implications factors in mechanisation and automation could be enhanced even more. This is also an attempt to address the issues of the country's dependency of foreign labours by encouraging the use of labour saving devices at an optimum cost. Promoting the use of IBS in construction using mechanisation and automation will surely improve the construction productivity and hopefully fulfil the Malaysian government's target of becoming a developed country by the year 2020. This statement is in lieu with Mahbub (2012) that highlighted the problems associated with the construction industry such as decreasing quality and productivity, labour shortages, occupational safety and inferior working conditions. Finally, there is also the need for an innovative solution within the industry, including the push for further use of industrialization, construction automation and robotics application on site in years to come.

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