

Factors Influencing the Implementation of Technologies Behind Industry 4.0 in the Malaysian Construction Industry

*Irrma Diana Mohd. Aripin**, *Emma Marinie Ahmad Zawawi*, and *Zulhabri Ismail***

¹Faculty of Architecture, Planning and Surveying, UiTM, Shah Alam, Malaysia

Abstract. Industry 4.0 is a concept which include Big Data and Analytics, Autonomous Robot, Simulation, System Integration, Internet of Things, Cyber Physical System, Cloud Computing, Additive Manufacturing and Augmented Reality. The makeover, not only completely change the way on how physical structures are designed, developed and preserved, but also how they are used in the future with applications of avant-garde technology. However there is a tendency that construction companies may be hesitant to invest in them. Industry 4.0 aims to motivate construction companies to adopt new technologies. Therefore, this paper aims to review on literature in identifying technologies that are used in line with Industry 4.0 as well as investigate the potential barriers faced and factors which influence the Industry 4.0 technologies implementation in the Malaysian construction industry. Relevant academic materials were reviewed thus the purpose of this paper is to present a literature review and critical analysis of the implementation of technologies behind Industry 4.0. Based on the results of the analysis, applications and uses, benefits, barriers and future needs are discussed. The results also reveal that the acceptance can help improves the image of the industry.

1 INTRODUCTION

The construction industry plays a crucial role in developing and increasing the economic sector and the country's development in construction industry. In 2014, [1] the 4th industrial revolution or Industry 4.0 has helped in transforming the economies, jobs and society. From the broad title "Industry 4.0", technologies, neither physical nor digital are combined through analytics, artificial intelligence, cognitive technologies and the Internet of Things (IoT) to ensure digital enterprises that are both interconnected and have the ability in making more informed decision-making, are created. This Industry 4.0 has been broadly discussed and has become a point of convergence for most global industries as well as the construction industry. In this context, Industry 4.0 shows that it encompasses a variety of technologies to allow the development of a digitised and automated manufacturing environment, including the digitisation of value chain [2]. According to the Ministry of International Trade and Industry of Malaysia, industries that are moving towards Industry 4.0 applications tend to gain an increasing flexibility, productivity, quality and in reduction time to market. However, even with the provided advantages, the construction industry companies still have not managed to consolidate these innovative technologies to keep up with their fellows from the automotive or mechanical engineering sector

[3]. In addition, there are many barriers, specifically that exist in the construction industry, where action must be taken. For instance, the whole construction value chain is greatly affected by tight collaborations with supplier, subcontractors and other stakeholders. Therefore this paper aims to review literature from past researchers in identifying factors that influence the implementation of technologies behind Industry 4.0 along with their potential barriers in the Malaysian construction industry.

2 CONSTRUCTION INDUSTRY AND THE INDUSTRY 4.0 REVOLUTION.

2.1 Introduction to Construction Industry

The construction industry can be considered as a unique industry as compared to other industries. This is because the characteristic of a construction project is complex and unique. For instance, each project has a different nature of work, workplace, personnel, turnover and different types of product and services. Construction is also known as a high-risk industry that involves a broad view of activities, including alteration, and work repairs, such as roadway paving, demolition works, excavations, residential construction and many more. There are many published research on the importance of contribution to the national economic development by construction industry. Therefore, Industry 4.0 is introduced to fulfil

* Corresponding author: zulhabri@salam.uitm.edu.my**, irmadiana@yahoo.com *

those demands. So, this paper will discuss how technologies behind Industry 4.0 works in regard to the construction industry in terms of its benefits and potential barriers faced by the industry during their implementation.

2.2 Industry 4.0 Revolution

Industry 4.0 is used as a popular term to describe the revolution for the increasing use of information and automation technologies in the manufacturing environment [4]. Industry 4.0 can also be described as the increasing digitisation and automation of the manufacturing environment as well as the creation of a digitised value chain to enable communication between products, their environment and business partners [5]. There are nine pillars of Industry 4.0, which are Big Data and Analytics, Autonomous Robot, Simulation, System Integration, Internet of Things, Cyber Physical System, Cloud Computing, Additive Manufacturing and Augmented Reality. These pillars will reconstruct production into a fully integrated, automated, and optimised production flow; thus, it can bring to a better efficiency and relation among suppliers, producers, and clients, including human-machine relation during change in traditional production [6].

2.3 Technologies Behind Industry 4.0

There are numerous technologies behind Industry 4.0 but this paper focuses on Building Information Modelling (BIM), Industrialised Building System (IBS), and Robotic in construction because in Malaysia, BIM has recently gained attraction from the construction players and some of them have applied it in several projects. With the application of BIM process, the construction players have the opportunity to plan, coordinate and design with an integrated approach. This is one of the many benefits that they could gain, resulting in increased productivity. Despite these benefits, the BIM implementation in the Malaysian construction industry, for instance, still lags behind Singapore, [7]; thus, this study focuses its warrants to study on the present to determine what are the barriers that hinder BIM implementation and what are the driving factors that enhance its implementation in the Malaysian construction industry. As mentioned by Othuman,[8] the construction industry in Malaysia is migrating from conventional methods to a more systematic and mechanised method known as the Industrialised Building System (IBS). Each state in Malaysia is currently examining the developments of the IBS and its potential benefits. Also the Ministry of International Trade and Industry (MITI) has clarified that the Malaysian government encourages automation in manufacturing to help reduce the reliance on manual labour; thus, it includes robotics application.

2.3.1 Building Information Modelling (BIM)

Smith (2014), indicated that a digital representation of the physical and functional criteria of a facility based on knowledge sharing resource for information, and then forming a reliable basis for decisions during its life-cycle would be the right definition of Building Information Modelling (BIM). This building information model is basically a 3D-digital representation of the fundamental aspect. Moreover, BIM also caters persistent and coordinated views and representations of the digital model along with reliable data for each view; thus, this technology gives advantage to the designer's time as it helps in coordinating each view through the built-in intelligence of the model. Therefore, BIM not only acts as a model during organising information about the building construction, which includes materials, methods, schedules, costs, and processes, but it can also be used as a model-based control system during the construction [9]. The use of BIM help to predict the cost of a construction project and it is an essential construction management skill [10]. This is a good element as the construction industry is looking forward to find more effective and efficient ways to estimate since the complexity of projects in the construction industry has now increased from time to time.

2.3.2 Industrialised Building System (IBS)

Based Based on [11], the current state of the Malaysian construction industry is still not adequate to meet the demands from other sectors. This happens due to insufficient quality, productivity and safety, as well as high dependency on inexperienced foreign labour. Therefore from the point of view, the Industrialised Building System (IBS) may offer some solutions in reducing the gap between these high demands and current low quality supply exhibited by the construction industry; thus, IBS implementation is established as the correct measure to increase capability among the industry rather than the conventional methods. IBS can be defined as a construction system where the components are manufactured in the factory and not at the project site [12]. Meanwhile in Malaysia, the Construction Industry Development Berhad (CIDB) indicates that the term IBS as a way of construction where the building components are manufactured at factories or off site, and then will be transported and assembled into a structure with minimum work. The implementation of IBS has shown to be more economical as applying it can help in saving costs, reducing incompetent labour, reducing building materials and is also comparatively efficient, safe and cleaner with improved and better quality. And, [13] also mentioned that IBS provides benefits, which include enhanced building quality. In fact, the implementation of IBS has encouraged the production of good quality materials in a short time and with lower material and labour costs [14]. Even though the IBS implementation can increase the productivity and efficiency in the construction industry, in the Malaysian construction

industry context, the main objectives of its implementation are more towards enhancing the overall quality of construction products and reducing dependency on foreign labour [15].

2.3.3 Robotics in Construction

Robotics as a whole is a combination of mechanical, electrical, and software engineering. According to [16], the act of designing, building, and applying robots is called as robotics. It involves the process of creating or renovating a building or an infrastructure facility; thus, this robotics element could potentially facilitate many construction processes to make them safer for workers, take up less time, or even perform simple tedious tasks [17]. The introduction of new robotics equipment can help to reduce time as well as reduce the potential risk exposure to the labourers. For instance, the usage of Unmanned Aerial Vehicle (UAV) in surveys, where UAV or drones are unmanned robots that are remotely controlled by a human interface and are used to accomplish various tasks. These types of robot come in different sizes and specifications. They can be small or large and fast or slow. UAV is an aircraft that has no on-board pilot, neither the operator nor the equipment, as well as the data link connecting the two. In fact, the term drone refers to the aircraft itself and involves equipment operated independent of human control [18]. This UAV is widely used for the survey and operation of other activities, such as quarry monitoring, archaeological site surveys, as well as 3D modelling for buildings. Furthermore, the usage of UAV has been widely used by construction company since it has the ability to gather views of the construction projects, starting from ground level, going through the project progress at different heights and viewpoints, then followed by views from above the site. With the application of robotics in the construction industry, there will be less aspects to worry about, such as no healthcare costs and only just the maintenance costs need to be of concern. In addition, the UAV implementation can also decrease the potential exposure risk to the employees. This is because the UAV is controlled from ground, and thus reducing the personal risk [19].

3 METHODOLOGY

This review takes a three-step approach: 1) identify academic journals and databases; 2) collect, store and filter relevant articles; and 3) perform data analysis.

3.1 Identify academic journals and databases

The first step is to identify the academic journals and databases that may contain any relevant material for this review.

3.2 Collect, store and filter relevant articles

Once publication was found, the abstract and keywords were reviewed to check whether it is relevant to the review. Those that are not, will be filtered out.

3.3 Perform data analysis

Once relevant materials have been collected, information regarding implementation of Industry 4.0 technologies are gathered, data analysis is performed. The data and discussion is presented in the next section.

4 FINDING

4.1 Benefits of Applying Industry 4.0 Technologies

Table 1 shows five examples of benefit in applying Industry 4.0 in the construction industry that were determined from past researchers, which include cost savings, time saving, improving quality, safety, and the industrial image.

Table 1: Benefits of Applying Industry 4.0 Technologies

Variable	Authors
Cost Saving	[14] [15] [20]
Time Saving	[14] [15] [17]
Improving Quality	[8] [13] [21]
Improving Safety	[17] [19]
Improving Image of Industry	[22]

According to [14], the IBS implementation has encouraged the production of good quality materials in a short period of time, and with lower material and labour costs. As a result it could help to save up cost. Supported by [15] which mentioned that the Malaysian construction industry has been too much dependent on unskilled foreign workers, especially from Indonesia, Bangladesh, Vietnam, Myanmar and Nepal since they are cheap labour and widely available; thus, in order to limit the inflow of foreign labours, the Government has tightened the requirement for work permits, increased the levy on foreign workers and encouraged the industry towards the usage of IBS. Therefore it can be seen that the IBS application contributes to cost savings. Moreover, the use of robotics can also result in a the reduction of labour costs [20]. Next, as stated by [14], the IBS implementation consumes a shorter time. Furthermore, when the dependency towards foreign workers has been reduced since the new advanced technologies is used, the time consumed can also be saved [15]. In addition, [17] also stated that the robotics element could potentially facilitate many construction processes to make them safer for workers, take up less time, or even perform simple tedious tasks. The usage of BIM in the construction industry helps to maintain the graphical elements and gives a data management environment which contributes to quality improvement [8]. This is followed by the application of IBS that results in a safer, cleaner and improved quality [13]. Next, BIM can efficiently improve collaboration and

communication even over the company borders [21]. As mentioned by Alexander, [17], the application of robotics takes up lesser time and is safer for the workers. For instance, the application of UAV can help gather views from different heights and viewpoints, which can reduce accident risks in workers. This is because UAV is controlled from the ground, and thus reducing accidents risk [19]. The construction industry is commonly known for its harsh working environment and its low level of digitisation leads to a poor employer image, and thus this digital conversion of the whole industry can help to improve the industry's image [22].

4.2 Potential Barriers in Applying Industry 4.0 Technologies.

Table 2 shows five examples of application barrier to Industry 4.0 in the construction industry. They were identified from previous researcher, such as economic implementation cost, acceptance of technology, higher requirement for construction equipment and process, lack of knowledge, and individual hesitance.

Table 2: Potential Barriers in Applying Industry 4.0 Technologies

Variable	Authors
Economic Implementation Cost	[22] [23] [24] [25] [5]
Acceptance of Technology	[26] [27] [24] [25]
Higher Requirement for Construction Equipment and Process	[28] [22]
Lack of Knowledge	[29] [30] [5]
Individual Hesitance	[31] [32] [33] [34]

According to [22] the Industry 4.0 technology implementation includes high cost of owning and using the technologies on site, and because some of the machines are still not fully developed, keeping up with the advances in technology can be more costly. Therefore construction industry is often not willing to put in high risk and costly investment into the technology. Supported by [23], the high cost for technical equipment, has become one of the barriers. Furthermore, a high cost is needed for training, educational external consultancy fees [24], [25]. Also, these barriers could also appear due to unclear understanding about the benefits of cost saving [5]. Another major reason that concerns the employees is in adopting new technologies is the jobless. Their perception about how they might be replaced by machines, computers or robotics [26], leads them to think twice about accepting those technologies. Next, as mentioned by [27], the uncertainty about how beneficial these technologies are considered to be a barrier that prevents the introduction and development of innovative technologies in construction. Hence, it can be said that this uncertainty affects the acceptance of the new technologies, in line with Industry 4.0. Furthermore, this barrier that appeared in the construction industry is

known for its strong resistance to move into new and advanced technologies [24]; thus, it leads to conservatism and affects the employee's ability to adapt with those technologies [25]. The construction industry projects are greatly affected by the external factors involved, such as weather, traffic and its surroundings. Hence, higher requirement for computing equipment used in the construction site environment, which are mostly outdoors, dust and humidity need to be taken into consideration [28]. Therefore as the work is closely related to the site, its implementation is affected by its locational conditions, such as weather and labour supply. Not only that, the difficulty in control and maintenance if these technologies are exposed to an "open" and unstructured environment of the construction site, where the machines have to work, can be the barrier to the Industry 4.0 technologies implementation [22]. Other than that, to move forward or transform into the new Industry 4.0 technologies requires a certain level of knowledge. Hence, the need for employee training and development [29], together with the increasing need for integration skills [30], since there are low technical competency of the construction workers on site; hence, there will be a huge challenge in order to create and develop new competencies to ensure the project organisation is optimised as well as to attract new talents to the workforce, such as employee with shared technical knowledge and integration experience as one of the main criteria. Moreover, in order to maintain a high implementation rate of robotics in construction, there must be enough supply of appropriate skilled operators to handle the machinery. Special training is also need for the formal learning of new skills and upgrading the on-site skills. On the other hand, lack of knowledge on the benefits of applying these Industry 4.0 technologies is also considered as the barrier [5].

According to [31], adopting new tools can affect in unintended changes in the way tasks are performed. Those changes can give an impact to the work organisation, workplace culture and productivity. There are experienced employees who are very keen to adopt the innovative solutions, but the burden to obtain the skills to successfully adopt those new technologies could be one of the barriers too [32]. Other than that, users' perception of easiness of implementing a technology plays an important role in technology adoption and implementation [33]. Lastly, [34] also mentioned that the other factor affecting users' perception of ease of use as well as technology advantage is their previous experience of using the technology itself.

5 Conclusion

The primary aim of this paper is to explore the current applications or the current practices of technologies that is in line with Industry 4.0, which relate to the Malaysian construction industry and provide the factors that influence the implementation of Industry 4.0 due to its benefits that could contribute as well as the potential barriers faced by the construction industry in the using the technologies from different perspectives. Based on

the investigation, it can be concluded that the Industry 4.0 implementation is far reaching the whole construction industry, the involved firms, the environment and also for employees. Besides the economic benefits, improving quality, productivity, efficiency and collaborations, their acceptance can help to increase safety; thus improves the image of the industry. Finally, the Industry 4.0 implementation concept can help the construction industry to transform into a technology-driven industry and to keep up with other industries in terms of performance improvement.

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