Application of Building Information Modeling toward Social Sustainability

N S A Rahim¹,4, S A S Zakaria², N Romeli¹, N Ishak¹, S Losavanh³

¹Faculty of Civil Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia
²School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, Penang, Malaysia
³Department of Civil Engineering, Faculty of Engineering, Suphanouvong University, Luangprabang City, Lao PDR

E-mail: nursoleha@unimap.edu.my

Abstract. Building Information Modeling (BIM) emerges as one of the megatrends that will modernize the Malaysian construction industry due to its vital role in collaboration, coordination and communication in real-time among construction industry stakeholders. In 2019, the government of Malaysia has mandated the use of BIM technology for public projects worths more than 100 million. However, less than half of the construction projects in Malaysia is currently using the BIM system. In order to encourage the implementation of BIM, there is an important need to educate the construction industry players with realistic information on BIM technology. Based on previous literature, disruption of BIM toward the traditional practice of construction activities can be managed through exposure and incremental of BIM knowledge. Therefore, this study explores the current awareness of construction industry players on the application of BIM toward sustainability aspects, particularly on social sustainability. A set of questionnaire survey is used to gather the required data and a total of 133 contractors have responded to the survey. The data were analyzed using the frequency distribution to indicate the highlighted application of BIM foresees by contractors that contribute to social sustainability. The finding indicates that the level of awareness is influenced by their knowledge on BIM. Therefore, providing a better understanding and wider exposure on BIM could improve the implementation of BIM in the construction projects, which align with the government agenda.

1. Introduction
In 2015, the government of Malaysia through its agency, the Construction Industry Development Board (CIDB) has commenced the Construction Industry Transformation Programme (CITP) 2016–2020, a five-year plan, which aims to transform the construction industry. The CITP has highlighted several issues that need to be addressed to improve the performance of Malaysia’s construction industry [1]. After the completion of the CITP, CIDB has launched the Construction 4.0 Strategic Plan (2021–2025) as the next step in the construction industry transformation journey. Construction 4.0 focused on embracing smart construction and moving toward the Fourth Industrial Revolution (IR4.0) [2]. There are twelve (12) technologies have been highlighted in the Construction 4.0 Strategic Plan to drive the transformation of Malaysian construction industry and one of the technologies is Building Information Modeling (BIM).
Currently, BIM emerges as one of the megatrends that will modernize the Malaysian construction industry due to its vital role in collaboration, coordination and communication in real-time among construction industry stakeholders. BIM can be classified as a revolutionary technology that transforms the way buildings are designed, planned, constructed and managed. In Malaysia, the National Cancer Institute located in Sepang Putrajaya was the first government’s project utilizing BIM [3]. The project shown a positive track record where the completion date was a head of schedule for two (2) weeks and was able to save the construction costs [4]. Despite the successful record of BIM implementation, Malaysia is still experiencing the slow uptake of BIM [5] and this scenario prevents the construction industry practitioners to fully utilize the actual benefits of BIM. Some factors identified in the previous studies that contribute to the slow uptake of BIM are lack of awareness and knowledge on BIM [6] as well as reluctant to change [7].

The construction industry is commonly regarded to practice conservative approach causing slow adoption toward innovation [8]. For example, the widely established Industrialise Building System (IBS) technology also yet to be fully utilized in construction projects in Malaysia [9]. A similar trend is observed for BIM adoption. Currently, only less than half of the construction projects in Malaysia are using BIM system [10]. To encourage the implementation of BIM, the Malaysian government has mandated a requirement of minimum 40% BIM Level 2 in a public project worth more than RM100 million [11]. By mandating BIM in public project, it shows the commitment of the government toward the implementation of BIM. However, to implement BIM in construction projects is perceived challenging since several hindering factors need to be firstly addressed. Therefore, this study is conducted to explore the level of awareness and knowledge of construction industry players on BIM, particularly on its contribution toward social sustainability.

Based on previous studies, numerous articles are related to the aspect of sustainability, however, studies that emphasize on the awareness of BIM contribution toward social sustainability are still lacking. Awareness and knowledge of construction stakeholders on BIM is considered as important to monitor the progress of BIM in the industry. In this context, this study will explore the current level of BIM awareness and knowledge, particularly on BIM contribution toward social sustainability. According to [12], the concept of social sustainability from the context of construction is related to the communities who are directly influenced by the construction project, such as industry, users and neighborhood communities. Through the implementation of BIM, it is perceived that a better and safer environment can be provided during the construction projects. Therefore, in this study, the determination of variables considered is depending on the potential impact and the use of BIM that is perceived will contribute toward social sustainability.

For example, performing design visualization will allow the client to understand more about the development of projects and able to identify potential problems in advance, prior to the construction process [13], hence improve the construction quality. This process will lead to a better quality of end-product and providing a better and safer environment. Therefore, a reliable advanced technology is required to facilitate the development of project to ensure it follows the definition of social sustainability. A wider understanding of the current knowledge of construction players on BIM, particularly toward social sustainability can assist in the preparation of proper strategy to provide evidential support and encourage the implementation of BIM in the construction projects. Through the exposure of more knowledge and awareness among construction players, it is anticipated to increase the implementation process and the findings would contribute to the body of knowledge, particularly in the construction management field.

2. Methodology
To achieve the objectives of this study, a quantitative approach was used where a set of questionnaire survey was developed and distributed to contractors from grade G1 to G7. The process of data collection was conducted via postal mail and during the BIM awareness programs organized by CIDB. By using both approaches, 133 valid responses were gathered. The background of the respondents is illustrated
in Figure 1 and Table 1, and the information about the organization participated in the survey is presented in Table 2.

Since this study aims to assess the awareness as well as knowledge of contractors related to BIM, the questionnaire was designed to suit it purposes by considering questions on the application of BIM that perceived to contribute to social sustainability. Based on the respondent’s awareness and knowledge, they were required to indicate which of the listed application of BIM could contribute to social sustainability. For the analyses of BIM contribution toward social sustainability, the percentage of respondents with more than 50% was considered as aware.

3. Results and Discussions
In general, the objectives of this study were achieved. The findings reveal awareness and knowledge of contractors in the Malaysian construction industry on BIM, particularly on its contribution toward social sustainability. Based on the analysis, 81% of the respondents are aware of the existence of BIM in the construction industry, however, only 53% of respondents possess knowledge on BIM with 27% having experience in using BIM as illustrated in Figure 2.
The findings are in line with the latest survey conducted by CIDB where the majority of the construction players are aware of BIM, thus, actions have been taken to align with the national agenda. Subsequently, further analysis was conducted to determine the knowledge of respondents on the contribution of BIM toward social sustainability. Out of the total number of respondents, only 53% of respondents were considered. This consideration is basically due to the reason for obtaining valid data, the respondents who did not possess any knowledge on BIM are not considered in further analysis. Figure 3 and Table 3 illustrate the awareness and knowledge of respondents on BIM contribution toward social sustainability.

**Figure 2.** Respondent’s Experience in handling BIM

**Figure 3.** The application of BIM toward Social Sustainability in Construction Phase.
By referring to Figure 3 and Table 3, only two BIM-related applications were aware by the respondents on its contribution toward social sustainability. The majority of respondents were only aware that enhance safety in construction site and increase labor productivity could contribute to social sustainability. Technically, all of the application of BIM listed above could contribute to social sustainability. For example, through the development of 3D model, different design options with different orientations of the building can be developed [14, 15]. Autodesk ECOTECT is one of the most common BIM-based analysis tools available and widely used in the market. By using this tool, the orientation of the building can be adjusted to obtain the optimized design based on the shading, heating and cooling mechanism. It can also be used to determine the vegetation and garden layout location [16]. The best building orientation can be selected on the basis of energy modeling and daylighting analysis that results in reducing energy consumption of the building [15, 17, 18]. These processes will provide the most ideal design, which can assist to improve the quality of the built product and provide a better living environment.

Apart from that, performing design visualization using the developed 3D model can assist in the identification of any collision (clashes) prior to the construction process [19], which reduce rework in the construction projects [20]. Inaccuracy and errors in design are usually caused rework and it potentially affect the duration of the project and quality of end-product [21]. Subsequently, rework will influence the productivity of workers in the construction site and increase the possibility of having accidents and injuries. Therefore, having a better collaboration between project stakeholders can prevent the occurrence of rework in the field [22] and produce a better and safer environment [23] as well as reducing the possibility of project delays. Although the findings indicate that only two (2) out of 14 listed applications of BIM are aware by the respondents on its contribution to social sustainability, some respondents are already had a sound knowledge and awareness of BIM. Therefore, exposing more information on BIM would increase the knowledge and awareness of construction players towards BIM and with that, it is anticipated to improve the implementation rate of BIM in Malaysia.

### 4. Conclusions

In Malaysia, BIM is still at a nascent stage of its development. Awareness and knowledge of the construction players is considered crucial in facilitating the process of BIM implementation. Providing a more reliable information and data is perceived necessary to assist in the decision-making process. Even though the awareness of construction players currently indicates a positive sign with mostly are aware of BIM, providing information and data related to sustainability aspects in future programs would provide a more holistic view on its application in the construction industry. The findings revealed that most of the respondents are still lacking in terms of awareness and knowledge of the contribution of

| Label | Application of BIM                                      | Percentage of Respondents |
|-------|----------------------------------------------------------|----------------------------|
| A     | Visualizing developed design                             | 36%                        |
| B     | Performing clash detection                              | 50%                        |
| C     | Reducing rework                                          | 44%                        |
| D     | Improving safety in construction site                   | 56%                        |
| E     | Improving collaboration                                  | 50%                        |
| F     | Reducing errors/omissions                               | 31%                        |
| G     | Enhancing scheduling and sequencing                     | 50%                        |
| H     | Reducing the overall project duration                   | 50%                        |
| I     | Increasing labor productivity                           | 53%                        |
| J     | Determining building’s orientation                      | 28%                        |
| K     | Determining sustainability material                      | 31%                        |
| L     | Design site and logistics management                    | 39%                        |
| M     | Building energy performance                             | 44%                        |
| N     | Performing analysis for daylight                        | 33%                        |
BIM toward social sustainability. Therefore, there is a need to incorporate the benefits of BIM implementation toward social sustainability in the content of organized seminar and program. By doing this process, it is anticipation to improve the development of BIM in the construction industry.

Acknowledgments
The authors acknowledge the Faculty of Civil Engineering Technology, Universiti Malaysia Perlis and School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia for the support. The authors appreciate the contributions of the organizations involved in the data collection process.

References
[1] Construction Industry Development Board (CIDB), Construction Industry Transformation Programme (CITP), 2016-2020. 2015: Kuala Lumpur.
[2] Construction Industry Development Board (CIDB), Construction 4.0 Strategic Plan (2021-2025), 2020: Kuala Lumpur. p. 96.
[3] Musa, S., et al. Building information modeling (BIM) in Malaysian construction industry: Benefits and future challenges. in AIP Conference Proceedings, 2018. AIP Publishing LLC.
[4] Latiffi, A.A., S. Mohd, and J. Brahim. Application of building information modeling (BIM) in the Malaysian construction industry: a story of the first government project. in Applied Mechanics and Materials. 2015. Trans Tech Publ.
[5] Ya’acob, I.A.M., F.A.M. Rahim, and N. Zainon. Risk in Implementing Building Information Modelling (BIM) in Malaysia Construction Industry: A Review. in E3S Web of Conferences. 2018. EDP Sciences.
[6] Haron, N.A., R.P.Z.A. Raja Soh, and A.N. Harun, Implementation of Building Information Modelling (BIM) in Malaysia: A Review. Pertanika Journal of Science Technology, 2017. 25(3).
[7] Al-Ashmori, Y.Y., et al., BIM benefits and its influence on the BIM implementation in Malaysia. Ain Shams Engineering Journal, 2020. 11(4): p. 1013-1019.
[8] Newman, C., et al., Industry 4.0 deployment in the construction industry: a bibliometric literature review and UK-based case study. Smart Sustainable Built Environment, 2020.
[9] El-Abidi, K.M.A., et al., Identifying and Evaluating Critical Success Factors for Industrialized Building Systems Implementation: Malaysia Study. Arabian Journal for Science and Engineering, 2019. 44(10): p. 8761-8777.
[10] Aziz, A. Govt aims 80% adoption of BIM system by 2025. Economy 2020 [cited 2021 1 February].
[11] Aziz, A. Govt Aims 80% Adoption of BIM System by 2025. 2020 [cited 2020 29 October].
[12] Almahmoud, E. and H.K. Doloi, Assessment of social sustainability in construction projects using social network analysis. Facilities, 2015. 33: p. 152-176.
[13] Migilinskas, D., et al., The Benefits, Obstacles and Problems of Practical Bim Implementation. Procedia Engineering, 2013. 57: p. 767-774.
[14] Lu, Y., et al., Building Information Modeling (BIM) for green buildings: A critical review and future directions. Automation in Construction, 2017. 83: p. 134-148.
[15] Taha, F.F., W.A. Hatem, and N.A. Jasim, Effectivity of BIM technology in using green energy strategies for construction projects. Asian Journal of Civil Engineering, 2020. 21(6): p. 995-1003.
[16] Azhar, S., J. Brown, and R. Farooqui, BIM-based sustainability analysis: An evaluation of building performance analysis software. in Proceedings of the 45th ASC annual conference, 2009.
[17] Shoubi, M.V., et al., Reducing the operational energy demand in buildings using building information modeling tools and sustainability approaches. Ain Shams Engineering Journal, 2015. 6(1): p. 41-55.
[18] Wong, K.d. and Q. Fan, Building information modelling (BIM) for sustainable building design. Facilities, 2013.
[19] Chen, C. and C. Tang, Development of BIM-Based Innovative Workflow for Architecture, Engineering and Construction Projects in China. International Journal of Engineering and Technology, 2019.
[20] Liu, Z., et al., A BIM-aided construction waste minimisation framework. Automation in construction, 2015. 59: p. 1-23.
[21] Lee, G., H.K. Park, and J. Won, D3 City project—Economic impact of BIM-assisted design validation. Automation in Construction, 2012. 22: p. 577-586.
[22] Lai, H., X. Deng, and T.-Y.P. Chang, BIM-based platform for collaborative building design and project management. Journal of Computing in Civil Engineering, 2019. 33(3): p. 05019001.
[23] Rajendran, S. and B. Clarke, Building Information Modeling: safety benefits & opportunities. Professional
Safety, 2011. 56(10): p. 44-51.