# A 3D BIM Integration in Risk Management for Construction Projects in Malaysia

**Nur Kamaliah Mustaffa, Che Maznah Mat Isa, Verona Ramas Anak Joseph**
Faculty of Civil Engineering, Universiti Teknologi MARA
40450, Shah Alam, Selangor, MALAYSIA
nurkamaliah@uitm.edu.my, chema982@uitm.edu.my, verona.ak.joseph@gmail.com

**Mohd Feisal Hafiz Abdul Aziz**
Public Service Department,
Federal Government Administrative Centre,
Complex C, 61250, Putrajaya, MALAYSIA
feisal.aziz@jpa.gov.my

## Abstract

Despite the inevitable recognition of Building Information Modeling or BIM across the industry worldwide, the use of BIM technology in developing countries is lagging. While BIM is extensively implemented in the design stage of the construction project, the integration of BIM in project risk management is yet broadened. This study has taken the first step in identifying the extent of practices of 3D BIM application in risk management for building construction projects in Malaysia. This study has been conducted using various approaches (guidelines review, close-ended questionnaire, and semi-structured interview) that have enabled the triangulation of information. The findings demonstrated that the integration of 3D BIM in risk management provides multiple potential benefits such as enhancing coordination and communication, early risk identification, inter-operability, and prediction of risks through visual risk analysis. Majority of respondents have revealed the lack of awareness and knowledge on the capability of BIM as a tool to manage risk with only a small percentage of construction organization practices 3D BIM in risk management process. A BIM-aided construction risk management would provide a guide for government agencies and construction practitioners in transforming disparate risk management process into a highly integrated system in construction projects.

## Keywords
3D-BIM, construction project, Malaysia, risk management

## 1. Introduction

Construction industry is known as complex, dynamic and volatile by nature which trigger the high uncertainty and risk. Risk management becomes a pivotal instrument in identifying and quantifying associated risks to exert influences on decision making in the construction process (Iqbal et al., 2015). The integration of risk management into the construction project has been recognized as an important mechanism for achieving project objectives in terms of quality, cost, time, and safety (Banaitiene & Banaitis, 2015). The latest efforts of managing risk by using ICT plays a key role in transforming the construction sector from a traditional to a digitalization process. Building Information Modelling (BIM) is a revolution of digital technology that can been used in risk management process to manage and respond to project risks. Several studies in literature has highlighted the development of BIM and BIM-related digital technologies for managing risks (Eastman et al., 2009; Zou et al., 2016; Zhang et al., 2013). The diffusion of BIM in managing risk could not only perform as one of the initiatives to enhance information management between organizations, but significantly driven by strong government roles in promoting the integration of ICT with risk management (Sinoh et al., 2020). Despite the wave of enthusiasm for BIM as a new design tools and management methods (Eastman & M., 2011), the challenges associated with BIM utilization in risk management still exists (Olanrewaju et al., 2020)). Zou et al. (2017) revealed that there are still a few technical limitations in the adoption of BIM-based risk management, where most of efforts in risk model development are still at a conceptual stage.

BIM has provided new impetus to the transformation of the landscape of the Malaysia construction industry. The revolutionary BIM tool presents great advantages towards realizing the Malaysia government vision in improving key performance indicator and productivity in construction sector (Enegbuma et al., 2014). While the BIM adoption has long been recognized in developed countries, the extent of BIM implementation to which this has changed on the Malaysian construction industry is continually been discussed by scholars. Numerous recent studies have concluded that the BIM level of acceptance in Malaysia is still in its infancy stage (Chan, 2009; Rogers et al., 2015; Sinoh et al., 2020; Low et al., 2020). Further evidence from literature has highlighted that BIM has been widely diffused at the planning and design stage and has yet to emphasize in the risk management context (Jin et al., 2019; Othman et al., 2020). Motivated by the vibrant and positive growth of BIM adoption in developing countries, this study aims to explore the current implementation of BIM in risk management, as well as the challenges faced by the industry on their practices of BIM application in risk management for building construction projects. This aim will assist in providing answer to the research question: "To what extent of BIM can be applied into risk management in Malaysia construction industry?". This paper could serve as a guide for government agencies and construction practitioner in transforming disparate risk management process into a highly integrated system in construction projects.

## 2. Literature Review

The subject of BIM adoption has received widespread attention in construction research due to the emerging of application of technologies in construction. The literatures of BIM development in Malaysia were observed on introducing the concept of BIM and BIM-related digital technologies. For example, Latiffi et al., (2013) have discussed on the general context of BIM including history, definition, concepts, issues and preliminary methods and tools. They explored on the integration of BIM into various construction life stages. Further studies on BIM landscape in Malaysia to include more-analytical based studies that provided evidences on the attitudes (Che Ibrahim et al., 2019) , benefits and problems (Memon et al., 2014; Latiffi et al., 2015) and the local implementation issues (Zahrizan et al., 2013; Latiffi et al., 2016; Othman et al., 2020). Numerous studies have proved that the adoption of BIM can bring multiple BIM benefits to the construction industry including minimize redundancies, increase project coordination, better communication and integration information within project management (Sinoh et al., 2020; Che Ibrahim et al., 2019; Husain et al., 2018). However, it is widely acknowledged in the construction literature that BIM adoption in Malaysia are still lagging. Cost of BIM, market condition, attitudes and behaviors, lack of enforceability mechanism, complexity and scarcity knowledge are categorized as related barriers to BIM implementation in Malaysia (Gardezi & Shujaa, 2013; Memon et al., 2014; Othman et al., 2020). Thus, this point to the need of intervention studies to contextualize the BIM development into the new paradigm by considering more practical views on the extent of BIM practices among construction stakeholders in Malaysia.

Risk management is an important field of construction industry and has gained more importance internationally due to the complexity and high degree of risk due to the nature of construction projects (Zou et al., 2015) suggested that BIM has a major potential to be integrated in risk management, although it has become more widely adopted in planning and design process. Park & Kim (2013) claimed that utilization of 3D site models has proven to improve the safety risk information. Zou et al., (2017) found that the current practice of risk management still experienced traditional undertaking, information fragmentation and reliance of multidisciplinary coordination which possess greater challenge in solving risks. They suggested that the foreseeable risk can be identified at early stage using the standard or government regulation while BIM-based tools could be used to deepen further risk analysis. Further studies by Zou et al., (2019) assimilated BIM in managing risk for highway project. They have affirmed that the incorporation of 3D BIM could improve risk identification process to resolve information sharing issue. Thus, there has been a growing need to deepen the understanding of the BIM establishment as a platform in managing and mitigating risks particularly in Malaysia context. This paper has briefly highlighted the level of BIM development in Malaysia and integration of BIM into risk management in the Malaysian construction industry. It is aimed to establish the current level of BIM implementation of BIM in risk management and identify the challenges faced by the industry on their practices of BIM application in risk management for building construction projects. Although there is diversity in the current thinking on the aspect of BIM development in Malaysia, there is still a lack of effort in assessing the potential of BIM tools in risk management domain. Consequently, this study has attempted to fill the gap by providing more practical views on the extent of BIM-based risk management development in Malaysia.

## 3. Methodology

The methodology process for this study is shown in Figure 3.1.

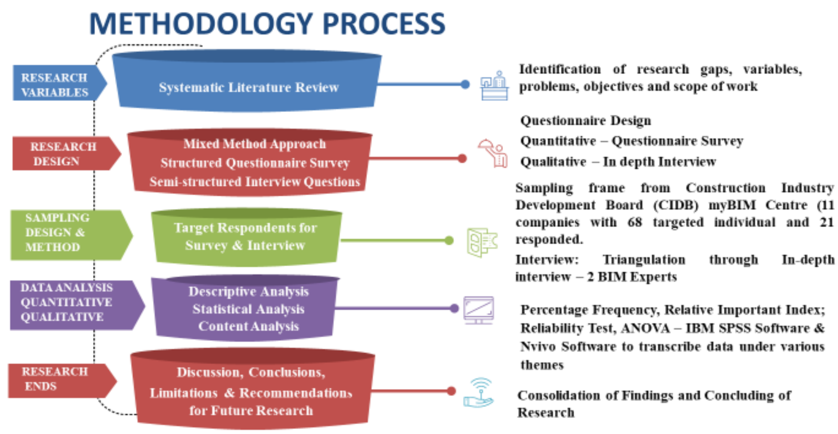


Figure 3.1. Methodology process

### 3.1 Identification of Research Gap and Variables

Initially, the research gap was identified, research objective and scope of work were determined. A systematic literature review was carried out where search string by using suggested keywords such as "BIM", "risk management", "3D Visualization" and "construction" to gather relevant materials. Some of the search queries derived from these keywords are "BIM – based risk management", "BIM for construction risk management" and "3D BIM application". The search strings were used in the online academic publication data base such as Scopus, ASCE, ScienceDirect, Emerald and Google Scholar. The papers were further trimmed to those published between 2010 to 2019 which were considered relevant to BIM and risk management in construction projects. A total of 20 from 50 journals were found related to 3D BIM and construction risk management.

### 3.2 Research Design

A mixed method research design was chosen using a quantitative approach based on questionnaire survey administered to the targeted respondents and complemented by the qualitative approach using semi-structured interviews with the experts.

### 3.3 Questionnaires Design and Measurement

First method is Likert scale questionnaire whereby this questionnaire was distributed to the construction companies recommended by myBIM Centre, Construction Industry Development Board of Malaysia (CIDB)'s National BIM Centre. In general, five – point scale ranging from 1 – 5 was adopted and established as follows; (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Agree, 4 = Agree, 5 = Strongly Agree). The questionnaire had three (3) sections as follows:

Section A: Respondent's demographic profiles
Section B: Information about 3D BIM application in project risk management
Section C: Strategies and challenges in implementing 3D BIM application in risk management.

### 3.4 Sampling Frame and Sampling Method

A sampling frame was obtained from the Construction Industry Development Board (CIDB), myBIM Centre. A purposive sampling was chosen to select the practitioner such as government agencies and construction companies listed by the myBIM Centre in the Malaysian construction industry.

### 3.5 Target Respondents for Survey and Participants for Interview

The sampling frame provides 11 registered companies with myBIM in which currently implementing BIM in their projects. These companies provide 68 a sampling frame for this study as shown in Table 3.1.

Table 3.1. Target respondents

| Name of Company | Target Respondents |
|---|---|
| Sime Darby | 6 |
| IJM | 5 |
| UEM | 8 |
| Sunway Construction | 11 |
| BIMAsia | 9 |
| Brunsfield International Group | 7 |
| 3d Tech Parametric | 7 |
| Kiara Teratai Sdn Bhd – NCI | 4 |
| KLCC Projeks Sdn Bhd | 6 |
| MRT Gamuda KVMRT | 5 |
| Total | 68 |

Using sample size determination from Krejcie and Morgan (1970), the sample size required is 58 number of respondents. Next, the interview sessions were carried out with two (2) BIM experts to triangulate the findings from the survey. The experts are from Construction Industry Development Board (CIDB) and Jabatan Kerja Raya (JKR) under Ministry of Works. who are pioneers in the government organization in BIM implementation in Malaysia.

### 3.6 Data Analysis

Statistical Package of Social Science (SPSS) version 25 software was used to analyze the questionnaire survey outcomes while NVivo 12a software was used to carry out the content analysis on the interview outcomes.

Quantitative analysis based on the collected information in the questionnaire was carried out using Relative Importance Index (RII) to rank the criteria according to their importance. Following is the formula of RII, which was inputted in Microsoft Excel 2016 to calculate the index:

$$RII = \frac{\Sigma w}{A \times N} \quad (1)$$

where w is the weighting as assigned by each respondent on a scale of one to five with one implying the least and five the highest. A is the highest weight and N is the total number of the sample. The relative importance index (RII) was used to rank multiple items within each section ($0 \leq RII \leq 1$). An item achieving a higher RII score would rank higher than those with lower RII values. The RII ranged from 0 to 1 and the foremost critical variables are close to one (Zakaria et al., 2013).

Next, ANOVA was also used to test whether the subgroups had consistent mean values in each section. Based on a 5% level of significance, a p-value lower than 0.05 would suggest that subgroup differences exist when perceiving the given item.

Finally, a content analysis was carried out to transcribe data from the interview sessions where the similarities were identified, themes were extracted, then the relationships were determined and explored to create associations and these have provided mapping of interactions of findings as the final stage data analysis.

### 3.7 Discussion of Findings and Concluding of Research

Finally, after the analysis was carried out, discussions based on the survey from 21 respondents and interviews with 2 subject matter experts from CIDB and JKR, were carried out respectively as presented in the following sections.

## 4. Results and Discussion based on Survey

This section is divided into two (2) parts, first is to discuss the results analysis on the current implementation of 3D BIM and second to discuss on the challenges faced by the industry on their practices of 3D BIM application in risk management for building construction projects.

### 4.1 Respondents' Demographic Profiles

Table 4.1 depicts the demographic characteristics of twenty-one (21) respondents' type of organization, their roles in organization, working experience in construction industry, academic qualification, organization operating years and number of projects using BIM application.

Table 4.1: Respondent Demographic Characteristics

| Demographic | Percentage Frequency |
|---|---|
| **Type of organization** | |
| Consultant | 38% |
| Contractor | 29% |
| Developer | 33% |
| **Role in organization** | |
| Construction Manager | 5% |
| Engineer | 56% |
| Modeler | 14% |
| Planning Manager | 10% |
| Senior Executive - Project Risk Management | 5% |
| Senior/Project Manager | 10% |
| **Working experience in the construction industry** | |
| < 10 years | 71% |
| 11 – 15 years | 24% |
| 16 – 20 years | 5% |
| **Academic qualification** | |
| Bachelor's degree | 76% |
| Master | 24% |
| **Company operating years** | |
| < 10 years | 33% |
| > 20 years | 48% |
| 11 – 15 years | 19% |
| **Number of projects using BIM** | |
| < 10 projects | 100% |
| 11 - 20 projects | 0% |
| 21 - 30 projects | 0% |

Twenty-one (21) out have responded resulted in a response rate of 36.2%. The percentage frequency shows similar distribution between the consultants, contractors and developers which are 38%, 29% and 33%, respectively. These companies were chosen due to involvement in construction projects and their ability and knowledge about the implementation and usage of BIM in the construction industry and on risk management process. Almost 56% of the respondents are engineers and most of them (95%) have between 5 to 10 years of working experience in construction industry. All of them have good academic qualification with 76% with bachelor's degree and 24% with master's degree. Since BIM application is relatively new as where all companies are currently using BIM in less than 10 projects.

### 4.2 Risk Management Process and Tools

The respondents' feedback on the risk management process shows that they have good understanding on the processes. The weightage score using relative importance index (RII) indicates "Risk Identification" process was ranked first followed by Risk Analysis, Risk Monitoring and Documentation, Risk Response Control and Risk Response Planning processes. According to Banaitiene (2012), risk identification is the basis for the next step which are analysis and control. Proper risk identification ensures the effectiveness of risk management. The weightage score of more than 0.700 for other risk management processes indicates that these processes are important and efficiently implemented (Smith et al., 2013). Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates as significant value ($F = 8.429$; Sig. = 0.008; $p < 0.05$). The results reveal that various organizations had significantly different views on "risk identification" in the risk management process where ($p$ – value < 0.05). Basically, consultant (mean = 4.13) and contractor (mean = 3.67) have the almost the same view while developers (mean= 4.86). This due to the nature and characteristic of a developer that is mostly involved from the beginning of the construction which requires them to conduct risk identification before starting the projects. With regards to 3D BIM application in risk management, Zou et al. (2019) suggested that the 3D visualization can be used in risk identification and risk analysis since it is proven that it can assist early risks identification and can provide visual risk analysis.

The most important tools ranked by the respondents using the RII weightage score are the Risk Impact Assessment and Cost-Benefit Analysis (0.857) tools followed by Risk Register (0.848), Risk Quantitative Probability Assessment and Simulation (0.829) and Checklist (0.762) tools. The respondents' feedback on the tools show that they have the knowledge and are currently using these tools in their risk management process for construction projects supporting the previous studies on risk management practices in Malaysia (Abdul-Rahman et al., 2015; Kang et al., 2015: & Karim et al., 2012). Analysis of variance (ANOVA) on the three subgroups' (contractor, consultant, and developer) indicates values of $F = 1.047$; Sig. = 0.0.372, where $p > 0.05$. The results reveal no statistically significant differences between groups as the $p$ – values are higher than 0.05. This means that all respondents from different organizations shared consistent views on risk management tools used in the projects.

### 4.3 Challenges in Managing Construction Projects

The respondents' feedback on the challenges faced in managing construction projects is shown based on ranking of the RII weightage scores. The findings show that "lack of information and knowledge" with RII = 0.857, is the main challenge in managing construction project risks. It was found that the knowledge on risk is fragmented and insufficient causing the risk knowledge transfer from one project to another project difficult (Sarkar & Shah, 2018). This could also indicate the reasons for no implementation of BIM for risk management in construction project in the Malaysian construction industry. In addition, lack of information has contributed to the low implementation of risk management in Malaysian construction industry (Abdul-Rahman et al., 2015). Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 1.047$; Sig. = 0.372, where $p > 0.05$. The results reveal no statistically significant differences between groups as the $p$ – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the main challenge in managing construction project due to lack of information and knowledge.

### 4.4 Importance of Risk Management in Construction Projects

Table 4.2 show the ranking of ten (10) statement on the importance of risk management in construction projects.

Table 4.2: Ranking on Importance of Risk Management in Construction Project

| Statement | Mean | RII | Rank |
|---|---|---|---|
| 1. Cost optimization | 4.476 | 0.895 | 1 |
| 2. Prevention of risks | 4.429 | 0.886 | 2 |
| 3. Ensuring successful completion of projects | 4.333 | 0.867 | 3 |

| | | | |
|---|---|---|---|
| 4. Increase productivity and quality of projects | 4.143 | 0.829 | 4 |
| 5. Achieving Projects goals and objectives | 4.143 | 0.829 | 4 |
| 6. Control project implementation | 4.095 | 0.819 | 6 |
| 7. Better strategic decisions | 4.095 | 0.819 | 6 |
| 8. Identification of project's strength, weaknesses, opportunities and threats | 4.095 | 0.819 | 6 |
| 9. Exploration of new opportunities | 3.762 | 0.752 | 9 |
| 10. Protection and Enhancement of shareholders values | 3.667 | 0.733 | 10 |

Despite the challenges faced by the respondents, the results reveal that all ten items are significantly important factors in using risk management with RII scores of higher than 0.700. This is because construction companies that manage risk effectively and efficiently enjoy financial savings, and greater productivity, improved success rates of new projects and better decision making (Banaitiene, 2012). Furthermore, Mering et al. (2017) also agreed that BIM was more useful in providing better tracking of cost control and cash flows. Therefore, it is highly significant to apply risk management by using BIM in the construction project. Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 0.815$; Sig. = 0.458, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the importance of risk management on cost optimization in construction project.

**4.5 Functions of 3D BIM in Construction Projects**

The respondents' feedback on the functions of 3D BIM in construction project indicate their knowledge and understanding on the importance of functions. Table 4.3 shows the ranking of the functions based on RII weightage scores.

Table 4.3: Ranking of Function of 3D BIM in Construction Projects

| Item | Mean | RII | Rank |
|---|---|---|---|
| 1. Visualization | 4.238 | 0.848 | 1 |
| 2. Coordination | 4.238 | 0.848 | 1 |
| 3. Clash Detection | 4.095 | 0.819 | 3 |
| 4. Risk Identification | 4.095 | 0.819 | 3 |
| 5. Risk Scenario Planning | 4.048 | 0.810 | 5 |
| 6. Fabrication/shop drawings | 4.000 | 0.800 | 6 |
| 7. Conflict Detection | 3.905 | 0.781 | 7 |
| 8. Space management | 3.857 | 0.771 | 8 |
| 9. Forensic analysis | 3.429 | 0.686 | 9 |
| 10. Code reviews | 3.238 | 0.648 | 10 |

The results show that visualization and coordination are ranked highest as the function of 3D BIM in construction projects (RII = 0.848). This is because visualization of preliminary design by 3D models could help engineers build and modify the model quickly in a parametric way to meet the stakeholders' requirements. In addition, the coordination in 3D BIM identified 3D geometric conflicts by comparing 3D models of building systems to eliminate field conflicts and coordination issues prior to installation (Zhou & Gao, 2016). Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 0.551$; Sig. = 0.586, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the most important function of 3D BIM in construction project which is visualization.

**4.6 BIM Implementation in Risk Management Process during Various Stages**

Table 4.4 shows the respondents' feedbacks where BIM can be implemented in risk management process during various construction stages.

Table 4.4: Ranking of Stages for BIM Implementation in Risk Management Process

| **Item** | **Mean (M)** | **RII** | **Rank** |
|---|---|---|---|
| Construction Planning | 4.286 | 0.857 | 1 |
| Construction Design | 4.190 | 0.838 | 2 |
| Construction Site Analysis | 4.048 | 0.810 | 3 |
| Construction | 3.905 | 0.781 | 4 |
| Facilities Management | 3.571 | 0.714 | 5 |

Despite lack of BIM application in their risk management process, the respondents agreed that planning stage was the most important stage where BIM can be implemented shown by the highest weightage score of 0.857 (M= 4.29), followed by the design stage (RII=0.838; M=4.190), site analysis stage (RII=0.810), during construction stage (0.781) while the lowest rank being during maintenance stage (0.714). According to Zou et al. (2016) identifying and mitigating risks should be carried out as early as possible, especially in the design and planning phases while the residual risks should be managed during the construction and subsequent phases. In addition, BIM can be used in risk management process during the early stages of the planning and design stages to avoid clashes and variation order (Khairi, 2019). Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 1.748$; Sig. = 0.202, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the most important stage to implement BIM in risk management process is during the planning stage.

**4.7 BIM's Potential in Managing Risks**

Table 4.5 presents the ranking of BIM's potential in managing risk for construction projects based RII weightage scores.

Table 4.5: RII Analysis for BIM's Potential in Managing Risks

| Item | Mean | RII | Rank |
|---|---|---|---|
| 1. Increase productivity and quality | 4.238 | 0.848 | 1 |
| 2. Enhance collaboration and communication | 4.190 | 0.838 | 2 |
| 3. Assist early risk identification and assessment | 4.143 | 0.829 | 3 |
| 4. Physical clash detection | 4.143 | 0.829 | 3 |
| 5. Interoperability | 4.143 | 0.829 | 3 |
| 6. Prediction and prevention of accidents | 4.143 | 0.829 | 3 |
| 7. Reduce project cost and delivery time | 4.048 | 0.810 | 6 |
| 8. Improving construction site layout | 4.048 | 0.810 | 6 |
| 9. Further risk analysis | 4.048 | 0.810 | 6 |
| 10. Conflicts management | 3.857 | 0.771 | 9 |

The results show that the top three BIM's potential in managing risk are increase in productivity and quality, enhance collaboration and communication and assists early risk identification and assessment which support previous studies by Diaz (2016), Park and Kim (2013) and Zou et al., (2017). Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 0.483$; Sig. = 0.586, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the most important BIM's potential which is to increase productivity and quality in construction projects.

Furthermore, BIM enables automatic detection of physical conflicts in the 3D model. Then 3D coordination can be used to generate document consisting building information and ensure same model is being shared between stakeholders to avoid conflicts. 3D coordination also identifies overlooked clashes and can assign the respective discipline to update the BIM structure model. While continuously monitor the facility element upon addition of new element using repetitive clash detection (Likhitruangsilp et al., 2016). Unfortunately, the current study shows a lack of information regarding where BIM can be used specifically on risk management apart from visualization and coordination. There are no proven studies for other BIM users in risk management.

### 4.8 Factors in Developing 3D BIM in Risk Management

In order to develop the 3D BIM in risk management, the respondents agreed that the most important factors to be considered based on the RII weightage scores are first, training (0.857), followed by the work process and team collaboration (0.848) while the third factor is the availability of tools (0.819). The fourth factor is the investment cost and ROI (0.800) followed by the fifth factor, the standard, regulations and legal issues (0.752) that need to be considered in order to develop 3D BIM in risk management process. Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 2.116$; Sig. = 0.149, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the most important factor which is training required in developing 3D BIM in risk management.

### 4.9 Risks involved in Risk Management Framework

Table 4.6 presented the type of risks that are focused in their organization's risk management process.

Table 4.6: Ranking of Risks

| Item | Mean | RII | Rank |
|---|---|---|---|
| Change of government law and policy | 4.429 | 0.886 | 1 |
| Deficiencies in drawing and specifications | 4.333 | 0.867 | 2 |
| Cost Overrun | 4.286 | 0.857 | 3 |
| Defective design | 4.143 | 0.829 | 4 |
| Accidents and Injuries | 4.000 | 0.800 | 5 |
| Material Shortage | 3.905 | 0.781 | 6 |
| Communication error among project team | 3.810 | 0.762 | 7 |
| Effect on Environment | 3.714 | 0.743 | 8 |
| Improper quality control | 3.714 | 0.743 | 8 |
| Low construction productivity | 3.381 | 0.676 | 10 |

Ranked as top three in RII scores, the most common type of risk focused by the respondent are change of government law and policy, deficiencies in drawing and specifications and cost overruns. This result is in the agreement with Abdul-Rahman et al. (2015), Banaitiene (2012) and Likhitruangsilp et al. (2016) in which the risks are included and mentioned as the key factors to delay in construction projects and ultimately will cause failure if not managed properly. Therefore, is it important to eliminate or reduce the risk by implementing BIM uses accordingly in the risk management process. Analysis of variance (ANOVA) on the three subgroups (contractor, consultant, and developer) indicates values of $F = 0.181$; Sig. = 0.836, where $p > 0.05$. The results reveal no statistically significant differences between groups as the p – value is higher than 0.05. This means that all respondents from different organizations shared consistent views on the most important risk involved which is the change of government law and policy.

## 5. Results and Discussion based on Qualitative Analysis

Based on the interview session carried out with two (2) experts on BIM from Government sector, the raw data was transcribed and put into NVivo for word count queries and content analysis. Word count is used in this research to identify pattern and theme more easily and to maintain analytic integrity according to Leech and Onwuegbuzie (2011). Then content analysis in NVivo is conducted to assist in understanding of the concept discussed in the interview.

### 5.1 BIM Definition

The definition of 3D BIM given by each of the experts differed from the published definitions, however both experts showed some conformity level with several authors (Eastman et al., 2011; Underwood & Isikdag, 2010) that 3D

BIM is a 3D modelling technology that represent building at site in a digital way and has digital information throughout the construction project. The result shows that the understanding of concept of BIM varies dependent on the sense in which it is implemented.

**5.2 Challenges in BIM Implementation**

The conducted interview revealed that both experts agreed that the main barriers are related to people, process and technology. In terms of people, the challenges are due to culture, attitude and competency. Expert 2 stated that some people do not like to learn new thing because this will increase their work scope and burden. This is validated by Bouras et al. (2015) who revealed that the reason for resisting BIM implementation is that they are comfortable or familiar with traditional method. Culture can also influence the implementation process; when there is no cooperation culture between construction players, BIM cannot be implemented effectively especially in project risk management. Furthermore, both experts added that lack of BIM knowledge and skill causes lack in competency in the BIM implementation as a tool in project risk management. In terms of process, the challenges are lack of time to implement, limited reference, lack of available training course especially for risk management process, no standard and work processes or mandate by the government. It is founded that currently there are no mandate from the government concerning implementing in every construction project due to its tediousness and there is currently lack of proven data about the efficiency in using BIM due to its unique characteristic (S. Umar, Interview, October 17, 2019). Lastly, in terms of technology. the challenges are initial cost of acquisition such as software cost, hardware cost and training or hiring new workers cost, ICT network capabilities, data location and storage space. This has been also mentioned by several authors such as Azhar (2011) and Eastman et al. (2011) that lag in BIM adoption is also due to technology.

The conducted interviews revealed that Expert 1 only stated the general implementation process widely and does not consist every construction phase while Expert 2 mentioned the implementation process starting from the client requirement until handover of the building to the Client. From the Expert 1 point of view, the implementation process is after BIM model is fully created, the construction phases start and updated during the construction phase. In the end the same model that has been updated will be passed to the facilities management contractor. While Expert 2 explained that the implementation process starts with the client's requirement in the construction project and after the responsibilities between stakeholder is determined. The BIM scope and objectives, BIM level and user are then determined before the BIM initiation can start. After that, the usage of BIM in each construction phase is determined. The BIM execution plan for the project is documented before developing the 3D model. Finally, the collaboration process needs to be determined before the tendering phase starts. At the end of the construction phase, the 3D model is delivered to the client.

## 6. Conclusion

This paper presents the current implementation of 3D BIM application in risk management process and the challenges faced by the practitioners namely: consultant, contractor, and developer in the Malaysian construction industry. It is concluded that the integration of 3D BIM in risk management provides multiple potential benefits such as enhancing coordination and communication, early risk identification, inter-operability, and prediction of risks. The visualization through 3D BIM would ease early identification of risk by locating and providing visual risk analysis. Most respondents have revealed the lack of awareness and knowledge on the capability of BIM as a tool to manage risks, which revealed that only a small percentage of construction companies are currently practicing the 3D BIM in risk management process. Validation of findings were carried out with the experts in BIM in terms of the challenges and effectiveness in BIM implementation in Malaysia. Considerations of the integration between traditional tools and BIM-related digital technologies in risk management could also be incorporated in future studies. Even though this study involved a limited number of respondents and experts, it significantly provides some practical insights into what extent of BIM can be applied into risk management to expedite the transformation of disparate risk management process into a highly integrated system in construction projects.

## References

Abdul-Rahman, H., Wang, C., & Mohamad, F. S. (2015). Implementation of Risk Management in Malaysian Construction Industry : Case Studies. *Journal of Computing in Civil Engineering*, *2015*.

Alkaf, N., Karim, A., Rahman, I. A., Memmon, A. H., & Jamil, N. (2012). Significant Risk Factors in Construction Projects : Contractor ' s Perception. *IEEE Colloqium on Humanities, Science & Engineering Research (CHUSER2012)*, *Chuser*, 351–354.

Banaitiene, N. (2012). *Risk Management in Construction Projects* (A. B. E.-N. Banaitiene (ed.); p. Ch. 19). IntechOpen. https://doi.org/10.5772/51460

Banaitiene, N., & Banaitis, A. (2015). Risk management in construction projects إدارة المخاطر في مشاريع البناء. *Technological and Economic Development of Economy*. https://doi.org/10.3846/20294913.2014.994582

Chan, T. K. (2009). Measuring performance of the Malaysian construction industry. *Construction Management and Economics*. https://doi.org/10.1080/01446190903233137

Che Ibrahim, C. K. I., Mohamad Sabri, N. A., Belayutham, S., & Mahamadu, A. (2019). Exploring behavioural factors for information sharing in BIM projects in the Malaysian construction industry. *Built Environment Project and Asset Management*, *9*(1), 15–28. https://doi.org/10.1108/BEPAM-02-2018-0042

Eastman, C., Lee, J. min, Jeong, Y. suk, & Lee, J. kook. (2009). Automatic rule-based checking of building designs. In *Automation in Construction*. https://doi.org/10.1016/j.autcon.2009.07.002

Eastman, & M., C. (2011). BIM Handbook Introduction 1.0. In *BIM Handbook : A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*.

Enegbuma, W. I., Aliagha, U. G., & Ali, K. N. (2014). Preliminary building information modelling adoption model in Malaysia A strategic information technology perspective. *Construction Innovation*, *14*(4), 408–432. https://doi.org/10.1108/CI-01-2014-0012

Gardezi, S., & Shujaa, S. (2013). Prospects of Building Information Modeling (BIM) in Malaysian Construction Industry as Conflict Resolution Tool. *Journal of Energy …*, *3*(11), 346–350. http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=22250573&AN=93477995&h=yC7EUgAsW1DLGbpNnyaAHNDK0bIWWSLeZXaMshvuaP2ypVxe1xXfF6K6n9LXWkl5CpK7VYIqFpTy5q59SbLRQA==&crl=c

Husain, A. H., Razali, M. N., & Eni, S. (2018). Stakeholders' expectations on building information modelling (BIM) concept in Malaysia. *Property Management*, *36*(4), 400–422. https://doi.org/10.1108/PM-02-2017-0013

Iqbal, S., Choudhry, R. M., Holschemacher, K., Ali, A., & Tamošaitienė, J. (2015). Risk management in construction projects. *Technological and Economic Development of Economy*, *21*(1), 65–78. https://doi.org/10.3846/20294913.2014.994582

Jin, R., Zou, P. X., Li, B., Piroozfar, P., & Painting, N. (2019). Comparisons of students' perceptions on BIM practice among Australia, China and UK. *Engineering, Construction and Architectural Management*, *26*(9), 1899–1923. https://doi.org/10.1108/ECAM-07-2018-0275

Kang, B. G., Fazlie, M. A., Goh, B. H., Song, M. K., & Zhang, C. (2015). Current Practice of Risk Management in the Malaysia Construction Industry – The Process and Tools / Techniques. *International Journal of Structural and Civil Engineering Research*, *4*(4), 371–377. https://doi.org/10.18178/ijscer.4.4.371-377

Krejcie, R. V, & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *30*, 607–610.

Latiffi, A. A., Brahim, J., & Fathi, M. S. (2016). Transformation of Malaysian Construction Industry with Building Information Modelling (BIM). *MATEC Web of Conferences*, *66*. https://doi.org/10.1051/matecconf/20166600022

Latiffi, A. A., Mohd, S., & Brahim, J. (2015). Application of Building Information Modeling (BIM) in the Malaysian Construction Industry: A Story of the First Government Project. *Applied Mechanics and Materials*, *773– 774*(May 2012), 996–1001. https://doi.org/10.4028/www.scientific.net/amm.773-774.996

Latiffi, A. A., Mohd, S., Kasim, N., & Fathi, M. S. (2013). *Building Information Modeling ( BIM ) Application in Malaysian Construction Industry*. *2*(January 2013), 1–6. https://doi.org/10.5923/s.ijcem.201309.01

Likhitruangsilp, V., Malvar, M. J. S., & Handayani, T. N. (2016). *Implementing BIM Uses for Managing Risk in Design-Build Projects*.

Low, W. W., Abdul-Rahman, H., & Zakaria, N. (2020). Organisational culture of Malaysian international construction organisations. *International Journal of Construction Management*. https://doi.org/10.1080/15623599.2018.1484552

Memon, A. H., Rahman, I. A., Memon, I., & Azman, N. I. A. (2014). BIM in Malaysian construction industry: Status, advantages, barriers and strategies to enhance the implementation level. *Research Journal of Applied Sciences, Engineering and Technology*, *8*(5), 606–614. https://doi.org/10.19026/rjaset.8.1012

Mering, M. M., Aminudin, E., Chai, C. S., Zakaria, R., Tan, C. S., Lee, Y. Y., & Redzuan, A. A. (2017). Adoption of Building Information Modelling in project planning risk management Adoption of Building Information Modelling in project planning risk management. *IOP Conference Series: Materials Science and Engineering*. https://doi.org/10.1088/1757-899X/271/1/012043

Olanrewaju, O. I., Chileshe, N., Babarinde, S. A., & Sandanayake, M. (2020). Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Engineering, Construction and Architectural Management*. https://doi.org/10.1108/ECAM-01-2020-0042

Othman, I., Al-Ashmori, Y. Y., Rahmawati, Y., Mugahed Amran, Y. H., & Al-Bared, M. A. M. (2020). The level of Building Information Modelling (BIM) Implementation in Malaysia. *Ain Shams Engineering Journal*, *xxxx*. https://doi.org/10.1016/j.asej.2020.04.007

Park, C. S., & Kim, H. J. (2013). A framework for construction safety management and visualization system. *Automation in Construction*. https://doi.org/10.1016/j.autcon.2012.09.012

Sarkar, D., & Shah, H. (2018) . Intergration of BIM and Risk Management: A Review of Literature. *International Journal of Management, Technology and Engineering*, *8*(9), 489–499.

Sinoh, S. S., Othman, F., & Ibrahim, Z. (2020). Critical success factors for BIM implementation: a Malaysian case study. *Engineering, Construction and Architectural Management*. https://doi.org/10.1108/ECAM-09-2019-0475

Smith, N. J., Merna, T., & Jobling, P. (2013). *Managing Risk in Construction Projects* (3rd Editio). Wiley - Blackwell.

Zahrizan, Z., Ali, N. M., Haron, A. T., Marshall-Ponting, A., & Hamid, Z. A. (2013). Ijret_110208060. *Exploring the Adoption of Building Information Modelling (Bim) in the Malaysian Construction Industry: A Qualitative Approach*, *eISSN pISS*, 2319–1163.

Zhang, S., Teizer, J., Lee, J. K., Eastman, C. M., & Venugopal, M. (2013). Building Information Modeling (BIM) and Safety: Automatic Safety Checking of Construction Models and Schedules. *Automation in Construction*. https://doi.org/10.1016/j.autcon.2012.05.006

Zhou, H., & Gao, H. (2016). Application of the Visualization of BIM Technology in Construction. *International Conference on Construction and Real Estate Management*, 97–102. https://doi.org/https://doi-org.ezaccess.library.uitm.edu.my/10.1061/9780784480274.012

Zou, Y., Jones, S. W., & Kiviniemi, A. (2015). BIM and Knowledge Based Risk Management System A Conceptual Model. *Proceedings of CitA BIM Gathering 2015*, 63–68.

Zou, Y., Kiviniemi, A., & Jones, S. W. (2016). Developing a tailored RBS linking to BIM for risk management of bridge projects. *Engineering, Construction and Architectural Management*, *23*(6), 727–750. https://doi.org/10.1108/ECAM-01-2016-0009

Zou, Y., Kiviniemi, A., & Jones, S. W. (2017). A review of risk management through BIM and BIM-related technologies. *Safety Science*, *97*, 88–98. https://doi.org/10.1016/j.ssci.2015.12.027

Zou, Y., Tuominen, L., Seppänen, O., & Guo, B. H. (2019). Visualisation of Risk Information in BIM to Support Risk Mitigation and Communication: Case Studies. In Advances in Informatics and Computing in Civil and Construction Engineering (pp. 239-246). Springer, Cham.

## Biographies

**Nur Kamaliah Mustaffa** is a Senior Lecturer at the Faculty of Civil Engineering, Universiti Teknologi MARA, Malaysia. She holds a Ph.D. Degree in Civil and Environmental Engineering (Sustainability in Construction) from the University of New South Wales, Sydney, Australia. She is currently leading a project on carbon reduction strategies in construction funded by the Ministry of Education, Malaysia, and has been involved in several project collaborations with public and private organizations mainly focuses on low-carbon city and sustainable development initiatives. She has more than 10 years of accumulated teaching experience in the domain of construction engineering and project management including risk management, construction project management, construction technology, sustainability, and environmental engineering courses. Her research mainly concentrates on the area of sustainability in construction which focuses on developing the optimization simulation modeling for environmental and economical solutions, sustainable impact assessment, risk management, green building and low carbon city and actively involved in publishing research outputs, paper reviewers, external panels and academic appointments at different institutional levels. She is registered as a certified Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) Qualified Professional (QP) and Qualified Assessor (QA).

**Che Maznah Mat Isa** is an Associate Professor at the Faculty of Civil Engineering, UiTM Malaysia and currently appointed as an Associate Director at Engineering Accreditation Department, Board of Engineers Malaysia (BEM). She obtained her BSc. (Civil Engineering) from University of North Carolina, Charlotte, North Carolina, USA and earned her MSc. (Integrated Construction Project Management) and Ph. D (Civil Engineering) from UiTM Malaysia. She is a Professional Engineer with Practicing Certificate (PEPC) registered with BEM and a member of Institute of Engineers Malaysia (IEM). She was the Head of Quality Unit at the Faculty of Civil Engineering, UiTM Shah Alam and appointed as the Project Manager with the Development Office, UiTM and has handled UiTM's projects all over Malaysia. Her employment experience as a lecturer started with the Federal Institute of Technology, Kuala Lumpur in 1991 then continued with UiTM until present. Some of the courses taught are civil engineering and project management courses i.e. integrated design project, engineering and resource management, international construction business, construction and facilities management, risk management, construction project management, construction business, technology entrepreneurship including supervising final year project, master dissertation and Ph.D students. Her research interests include engineering education, international construction project management and risk management.

**Verona Ramas Anak Joseph** was a Master student of MSc. in Construction Engineering program at the Faculty of Civil Engineering, Universiti Teknologi MARA, Malaysia under the supervision of Dr. Nur Kamaliah Mustaffa.

**Mohd Feisal Hafiz Abdul Aziz** is a Diplomatic and Administrative Officer, currently attached to the Public Service Department of Malaysia. His current role is to execute the policy made by the organization in developing human capital among government officers. He holds a Master's Degree in Engineering Science (Project Management) from the University of New South Wales, Sydney, Australia. He has 12 years' experience working in various fields such as project management, risk management, procurement, finance, and human resource management.