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Adoption of Building Information Modelling in project planning risk management

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Abstract. An efficient and effective risk management required a systematic and proper methodology besides knowledge and experience. However, if the risk management is not discussed from the starting of the project, this duty is notably complicated and no longer efficient. This paper presents the adoption of Building Information Modelling (BIM) in project planning risk management. The objectives is to identify the traditional risk management practices and its function, besides, determine the best function of BIM in risk management and investigating the efficiency of adopting BIM-based risk management during the project planning phase. In order to obtain data, a quantitative approach is adopted in this research. Based on data analysis, the lack of compliance with project requirements and failure to recognise risk and develop responses to opportunity are the risks occurred when traditional risk management is implemented. When using BIM in project planning, it works as the tracking of cost control and cash flow give impact on the project cycle to be completed on time. 5D cost estimation or cash flow modeling benefit risk management in planning, controlling and managing budget and cost reasonably. There were two factors that mostly benefit a BIM-based technology which were formwork plan with integrated fall plan and design for safety model check. By adopting risk management, potential risks linked with a project and acknowledging to those risks can be identified to reduce them to an acceptable extent. This means recognizing potential risks and avoiding threat by reducing their negative effects. The BIM-based risk management can enhance the planning process of construction projects. It benefits the construction players in various aspects. It is important to know the application of BIM-based risk management as it can be a lesson learnt to others to implement BIM and increase the quality of the project.

1. Introduction

One of the major industries that contribute to Malaysian economy is the construction industry. Through provision of basic infrastructure, the industry continues to support social development. In everyday life in an organization and projects, there is always uncertainty [1], representing a clear danger to the business, but also in it significant opportunity that must be taken [2]. Risk may serves as opportunities, but the fact that most risks usually have negative results led individuals to only consider



the negative side of the risk [2, 3]. Today risk management is important in project management, where one of the most difficult activities is determining what are the project's risks and how should they be prioritized [4].

Adoption of BIM can be implemented to all construction project phases, which are pre-construction phase, construction phase and post-construction phase [5, 6]. According to Furneaux and Kivit [5], the BIM application in construction projects helps in controlling the project efficiently. The design process decision is facilitated by the ability of the adoption of BIM to foster collaboration between construction players. Besides, time and construction cost can be reduced during the design stage with the detection of clash and clash analysis. Strategies and technologies as management tools is critical to minimize the dispute occurrence [7]. Hence, construction players play a big role in realizing the benefits of BIM in improving the implementation of construction processes. It is true that BIM is still in the early phase of introduction in Malaysian construction industry. Even though BIM is seen as an expensive technology to be implemented, but it has proven to provide a lot of solution [8].

2. Literature review

2.1 Adoption of risk management using BIM in the project planning phase

Planning is a basic part of contracting and the construction process. In the projects that implement BIM, visualizations can be made from previously produced models, in contrast to the traditional projects, in which the building visualization had to be made from the very start. With the speedy development of theory and computer applications over the last few years, BIM has achieved a remarkable awareness in the construction industry. According to Volk *et al.* [9], there is a compelling increase of the implementation of BIM to support planning, design, construction operation and maintenance phases. According to Porwal and Hewage [10], BIM is systematic method and process that is changing the project delivery, designing [11] and the communication and organisational management of construction [12] instead considering technology. Table 1 presents the process of implementing BIM can be seen as a systematic way for managing risks in the project planning phase.

Table 1. Examples for applying or developing BIM-based risk management in the project planning stage [13]

BIM-based Risk Management Functionality	Benefits for risk management	Research
3D Visualisation	Facilitating early risk identification and risk communication	Hartmann <i>et al.</i> [14]
Clash detection	Automation of detecting physical conflicts in model	Hartmann <i>et al.</i> [14], Tang <i>et al.</i> [15]
4D construction scheduling/ planning	Improving construction management level by facilitating early risk communication and risk identification	Hardin [12], Hartmann <i>et al.</i> [14], Whyte [16]
5D cost estimation or cash flow modeling	Planning, controlling and managing budget and cost reasonably	Hardin [12], Hartmann <i>et al.</i> [14], Whyte [16], Marzouk and Hisham [17]
Construction progress tracking	Quality, safety, time and budget management level can be improved	Bhatla <i>et al.</i> [18], Eastman <i>et al.</i> [19]
Safety management	Personnel safety hazards reduced	Whyte [16], Teizer [20]
Space management	The consideration of space distribution and management in design can be improved	Hartmann <i>et al.</i> [14], Kim <i>et al.</i> [21]
Quality control	Construction quality is improved	Chen and Luo [22]
Structural analysis	Structural safety is improved	Lee <i>et al.</i> [23], Sacks and Barak [24], Shim <i>et al.</i> [25]
Operation & maintenance facilities management (O&M), management (FM)	Management level is improved and risks are reduced	Becerik-Gerber [27], Volk <i>et al.</i> [28]
Urban planning and design	Land-use planning, design and management can be facilitated by integrating planning and design of urban space and AEC projects	Kim <i>et al.</i> [21], Lee <i>et al.</i> [23] Rajabifard [29]

From the beginning of the project, BIM can be used freely. BIM can be used as a strong and effective process in the intimate combination of the designer and the builder. Design Model and Construction Model can be identified when BIM is used. Design Model which is developed by the engineers and architect are expected to be completed at the level of detail of 2D construction documents. Construction Model is developed by the contractor and subcontractor where it consists of the modelling of shop drawings and related information. Developer from each distinct model can work and update their own files and are given the responsibilities for the dimensional accuracy of model. To form a federated model, distinct models can be linked to each other. The federated model can be used for various purposes. This includes clash detection, marketing and facilities maintenance. According to Westin and Sein [30], with the use of a 3D model, quantities, boards of objectives and production meetings, BIM should be part of the daily agenda. The reinforcement in the production phase of civil works, information of steel and concrete can be obtained by using BIM. Westin and Sein [30] said that the information of the stages of the concrete casting, quality and its characteristics can be found in the 3D model.

3. Methodology

Despite having all of the information from the literature review, a further research is still needed in order to achieve the study's aim and objectives. In order to obtain data, respondents selected are not only those who utilize BIM, but also those who understand and apply the concept of risk management in construction. 70 respondents are targeted to answer the questionnaires. A quantitative approach is adopted in this research as it is more reliable and objective. It reduces and restructures a complicated problem to a limited number of variables. The questionnaire is parted into four parts. Section A is the respondent's personal details, Section B is to identify the risk management practices, Section C is to determine the best functions of BIM in risk management and Section D is used to investigate the efficiency of adopting BIM-based risk management during the project planning phase. The data obtained will be analysed using Statistical Package for the Social Sciences (SPSS) software. Data collected from questionnaires are transformed from raw data into meaningful information that can be used to analyse and achieve research objectives. Once data have been collected and data file are formed, the next step is to analyse the data to make statistical estimates and reach conclusions.

4. Result and discussion

4.1. Respondents personal details

According to the result collected, the questionnaires distributed showed 42.86% of response rate. Figure 1 shows the respondent's background. There were 60% respondents from civil and structure, 13% were quantity surveyor, 10% were mechanical and electrical, 7% were architect. Other than these, the other 10% were from turnaround engineering, construction management and safety, health and environment.

One's education level is usually related to their management level. Most diploma level entries are usually at the level of junior executive. However, this is also depending on their years of experience in the industry. Those who handle risk management are usually those who have bachelor degree and higher level. This is because risk management requires more attention and only be managed by the professionals. Figure 2 show the respondent's education level respectively. The respondents were mostly bachelor degree graduate in which they sit on the middle executive level.

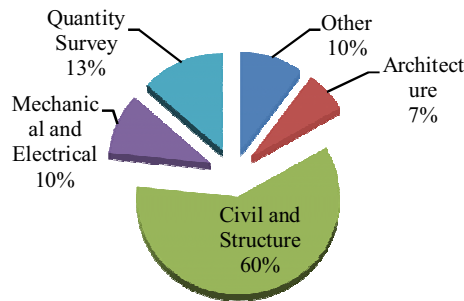


Figure 1 Respondent's Professional Discipline.

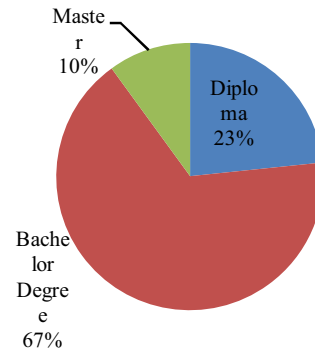


Figure 2 Education Level.

4.2. Risk management practice

Traditional risk planning relies on gut-feelings, based on experience and manual observation using 2D drawings. There are some respondent who mentioned that it is based on analysis and five whys method. One of the five whys method is drawing based, depending on what type of activity that is going to be conducted. Almost majority agreed on practicing identifying risk based on experience, with 83.33% of response rate. From figure 3, many identified risk based on experience. However, there were some issues that they encountered during the implementation of traditional methods. This can be seen in figure 4.

Throughout the project lifecycle, risks can be changed. However, this can only happens when the controls are in match. Although risks are always treated as challenges, it poses opportunities as well. According to table 2, the descriptive statistics showed that most company preferred to reduce risks, with variance value of .478.

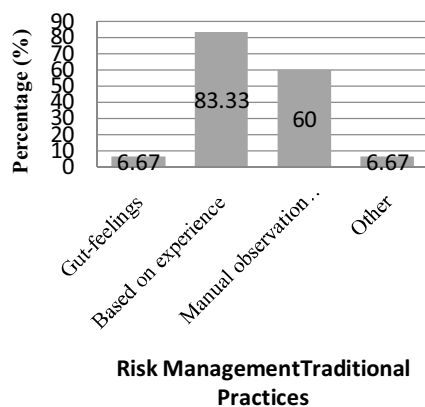


Figure 3 Risk Management Traditional Practices.

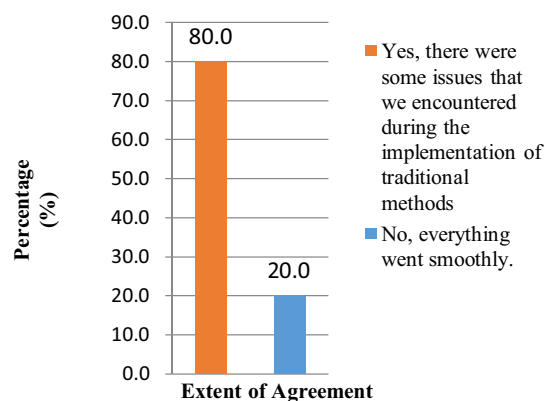


Figure 4 Collaboration Issues Using Traditional Practices.

With variance value of 1.253, avoiding risks seem to be difficult to be done as it can caused quality risks, personnel risks, cost risks and dateline risks. Table 3 is the Kaiser-Meyer-Olkin and Bartlett's Test (KMO) in which it was recorded that the value is 0.677 where this means that the data collected were reliable.

Table 2 Descriptive Statistics of Agreement in Position of the Company Handle Risks.

Handling Risk	Mean	Std. Deviation	Variance
Tranferring risks	3.0667	1.11211	1.237
Avoiding risks	3.3000	1.11880	1.252
Accepting risks	3.3333	.84418	.713
Reducing risks	4.0667	.69149	.478

Table 3 KMO and Bartlett's Test of Agreement in Position of the Company Handle Risks.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.677
Bartlett's Test of Sphericity	Approx. Chi-Square	10.985
	df	6
	Sig.	.089

4.3. Best function of BIM in risk management

According to Furneaux *et al.* [18], BIM is seen as a concerted action to ensure collaboration between construction players such as architects, engineers and contractors. According to the data collected in Table 4, BIM was seen to be more useful in providing better tracking of cost control and cash flow with variance of .178. This can concludes that BIM has many uses in project planning as the tracking of cost control and cash flow give impact on the project cycle to be completed on time. As BIM is still considered new in Malaysia, it is still not up to the level of managing the facilities. This can be seen related to the variance value of .322 where BIM was considered also useful but with standard deviation of .56765, not many picked on this potential. Figure 5 is the answer of the respondents.

Table 4. Descriptive Statistics of the Agreement in relation to the Potential Benefits of using BIM.

Code	Potential Benefits	Mean	Std. Deviation	Variance
P1	Decreases costs of utility demand and demolition	4.0000	.47140	.222
P2	Manages facilities proactively	4.1000	.56765	.322
P3	Provides better tracking of cost control and cash flow	4.2000	.42164	.178
P4	Identifies schedule phasing issues	4.3000	.48305	.233
P5	Enables project manager and contractor to see construction work sequence, equipment and materials	4.3000	.48305	.233
P6	Enables generation of takeoffs, counts and measurements directly from a 3D project model	4.4000	.51640	.267
P7	Facilitates better communication and increase design effectiveness	4.5000	.52705	.278

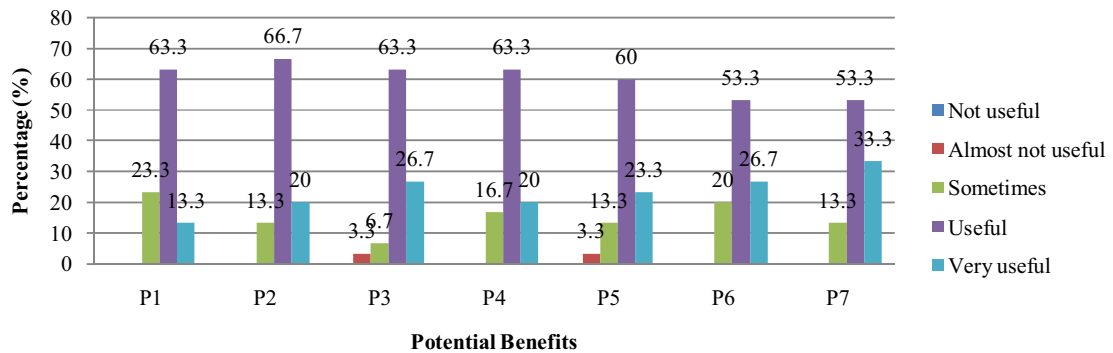


Figure 5. Percentage of the Extent of Agreement in Relation to the Potential Benefits of using BIM.

Table 5 is the Kaiser-Meyer-Olkin and Bartlett’s Test (KMO) in which it was recorded that the value was 0.712 where this means that the data collected were reliable.

Table 5. KMO and Bartlett’s Test of the Extent of Agreement in Relation to the Potential Benefits of using BIM.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.712
Bartlett's Test of Sphericity	Approx. Chi-Square
	138.768
	df
	21
	Sig.
	.000

As regards to figure 6 and table 6, 5D cost estimation or cash flow modelling had been chosen as the almost always effective way for managing risk with the variance value of 0.178. 5D cost estimation or cash flow modelling benefit risk management in planning, controlling and managing budget and cost reasonably.

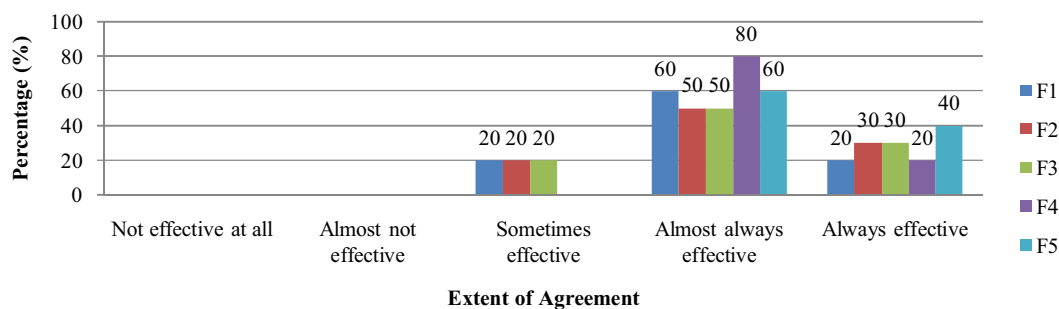


Figure 6. Percentage of the Extent of Agreement in Relation to BIM as a Systematic Way for Managing Risks.

4.4. BIM-based risk management in project planning phase

According to Zhou *et al.* [31], risk management had becomes proactive approaches rather than reactive. Although before the construction phase started, there is no project that challenges their risk issues [32], project manager could have predicted the risks [33] if appropriate risk identification were done. Without any doubt, risks exist in various stages of the project. The project lifecycle and the performance of the risk management have a forward impact on the project’s successfulness. There are

many factors that can lead to a successful BIM-based technology in risk management during the project planning phase.

In reference to table 6, there were two factors that mostly benefit a BIM-based technology which were formwork plan with integrated fall plan and design for safety model check.

Table 6. Descriptive statistics of the factors lead to a successful BIM-based technology in risk management.

Code	Factors	Mean	Std. Deviation	Variance
L1	Formwork plan with integrated fall protection	4.1000	.31623	.100
L2	Design for safety model check	4.1000	.31623	.100
L3	Hazard identification	4.2000	.42164	.178
L4	Reducing construction fatalities	4.2000	.42164	.178
L5	Safety protective equipment planning	4.2000	.42164	.178
L6	Minimizing documentation errors	4.3000	.48305	.233
L7	Replacing traditional delivery method with more integrated methods	4.4000	.51640	.267
L8	Reduced rework	4.5000	.52705	.278

Numerous investigations from Hartmann *et al.* [14], Shim *et al.* [25] and Zhang [34] have pointed out that there is a need to combine BIM-based and traditional risk management to improve practical applicability. Table 7 is the Kaiser-Meyer-Olkin and Bartlett's Test (KMO) in which it was recorded that the value was .768 where this means that the data collected were reliable.

Table 7. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.768
Bartlett's Test of Sphericity	Approx. Chi-Square	117.005
	df	28
	Sig.	.000

In conclusion, recognizing potential risks and turn it into chances is a strategy to avoid losses. Effective risk management must include in all areas, function and processes of the project.

5. Conclusion

This research addressed the topic of risk management and BIM, investigating the efficiency of adopting BIM-based risk management during the project planning phase. The objectives of this research were achieved throughout the process of literature review and questionnaires filled out by BIM experts and also those who understand and apply the concept of risk management in construction. The implementation of BIM in the AEC industry has been encouraged by the Malaysian Government to facilitate achievement of the vision of the CIDB Master Plan as well as the nation's 2020 vision through an increase in key performance indicators (KPIs) and productivity [6]. There are many benefits that each construction players can achieved with the adoption of BIM. Organization itself should educate their employees about the technology.

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