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RESEARCH ARTICLE

The Integration of Critical Risk with Building Information Modelling Application Strategies in Building Refurbishment Project Lifecycle

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ABSTRACT - Building refurbishment project has rapidly becoming a significant part of the construction industry in Malaysia. Refurbishment projects are typically higher risk, more complex, and require more coordination than new construction projects. Therefore, the aim of this research is to establish the integration of critical risk with Building Information Modelling (BIM) application strategies for building refurbishment project lifecycle improvement. This study is conducted through a quantitative method using the questionnaire which is distributed by employing a self-administrated approach as a research medium to obtain feedback from contractor grade 7 (G7) from construction organization who are registered with Construction Industry Development Board (CIDB) Malaysia. As a result, 96.5 percent of the response rate are accepted. The analysis shows that the integration of critical risk with BIM application strategies is recognized as important factors and strategies towards building refurbishment projects lifecycle improvement and found that the mean is in very high range. Additionally, the results indicate that the level of critical risk and BIM application strategies have been measured through descriptive analysis. The findings of this study are expected to establish a foundation for future research in order to develop an adequate framework for managing building refurbishment projects and improve the quality of decision making among the building industry professionals.

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1.0 INTRODUCTION

Refurbishment of buildings is becoming increasingly more not unusual to allow the provision of contemporary centres inside old buildings. It might be done in stages or all at once and on one hand preserves social cultural values and aesthetics of the building and on the other enables today's planners to rectify mistakes and revise older concepts employed by previous generations. Refurbishment works can be referred to the process of upgrading, conversions, modernizing and repairing an existing building in order to reuse it for variety of purposes [1]. Besides, the construction industry in Malaysia has been classified as a developing market for newly industrialized countries. However, the existing buildings in Malaysia are ageing, thus maintenance and refurbishment work is required to extend the life of the structure.

The refurbishment is due to some issues that occurred in construction industry which are limited vacant for new building [2]. This mostly due to a lack of available land for new development, the increase in number of ageing structures, imbalance stock of existing and new construction, and technological advancements [3,7]. Besides, there is a high demand for space and a limited supply of new construction cause the high cost of land, new construction is extremely expensive, particularly in metropolitan cities. Thus, most of the building owners decided that the best alternative is refurbishment [4,11,12].

At comparison to new construction, the risk in each phase of the project lifecycle is more complicated. Therefore, the nature of refurbishment is typically risky and distinctive, with existing and unsecured building conditions that can disrupt the project success. Currently, the refurbishment strategy is advantageous because it allows for the integration of long-term value with other building improvements [5]. In this regard, due to the high ratio of existing structures to new construction, which can exacerbate the environmental issue, this technique must be implemented [6].

The concepts of refurbishment principles include minimizing environmental effect and improving the performance of an existing structure to suit new criteria need to be implemented [7]. However, [8] stated that in refurbishing building projects, the projects are more complex and multi-dimensional; the measurement criteria have been expanded to include a broader variety of parameters that describe the job's nature. [9] mentioned that the intricacy of the scope of work, which is frequently risky and complicated, and may involve existing and insecure site conditions, determines the type and qualities of building refurbishment project.

Furthermore, current practice is traditional risk management method in building refurbishment project which is time-consuming, paper-based, and error-prone [10]. Thus, not in line with fourth Industrial Revolution (IR 4.0) initiative which needs a new approach of risk management? In the IR 4.0 era of digitization, the main concept of integrating and utilizing

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Building Information Modelling (BIM) technology application as a new innovation approach in facilitating risk strategies towards critical risk identification based on refurbishment project lifecycle is required [10]. BIM is a critical technology for integrated project management because it allows all project participants to access the latest information on building risk management, which is traditionally conducted. Thus, traditional risk management has to be improved from a manual technique to a more efficient strategy that uses Information and Communication Technology (ICT) to manage and strategize the project risks. Therefore, BIM may operate as a central database that supports in the entire process of managing the building lifecycle by making digital representations of the physical and functional information of sustainable projects available to all stakeholders [11]. It has enabled digital management of the entire lifecycle of buildings, including design, construction, operation, monitoring, and maintenance phases of sustainable projects, resulting in significant advances in project efficiency and cost control while reducing project risks. The principles of refurbishment implementation are one of the long-term strategies for reducing environmental impact and improving the performance of an existing structure to meet new standards.

1.1 Building Refurbishment Projects

Refurbishment may be considered a novel phenomenon, with a limited application. Particularly, the refurbishment is still a new field of management when compared to sustainable new construction. As a result, there are few studies on the approaches for managing this complicated building environment [11]. According to [12], Malaysia's construction industry, repair and maintenance work has a significant potential for expansion. Existing buildings in Malaysia are becoming obsolete, necessitating maintenance and refurbishment work in order to extend the life of the structure [13]. Since Malaysian building trends tend to follow those of developed countries, the refurbishment sector is expected to grow in Malaysia.

In addition, according to [14], refurbishment and energy efficiency upgrades of existing buildings are critical. However, their long-term viability rely on a sustainable, holistic approach in which energy-related efficiency methods are tightly linked to functional, construction, and economic objectives. Currently, the refurbishment is advantageous because it allows for the integration of long-term value with other building improvements [14,12]. This strategy is necessary in this case because of the overwhelming ration of existing buildings to new development, which can add to the environmental issues [15,10]. As stated by [16], when compared to the cost of constructing new constructions, refurbishment an old structure for reuse can save approximately 10 percent to 12 percent.

As a result, it can be stated that long-term value can only be obtained by integrating these principles, and that in order to survive, the refurbishment industry must improve its performance by developing appropriate strategies and metrics in relation to project performance criteria. One of the benefits of refurbishing an old structure over rebuilding one is that associated wastes can be avoided while embodied energy is preserved [17]. It is also cost-effective way to green existing buildings by reducing energy consumption, operating costs, and lifecycle costs, which leads to higher client investment returns. As a result, modernizing old infrastructure is crucial step toward achieving sustainability.

The building refurbishment project includes minimizing environmental effect and improving the performance of an existing structure to suit new criteria. However, most of the developing countries performance in building refurbishment projects is unsatisfactory. The importance of the refurbishment industry is expanding, as is the difficulty of project management and poor project outcomes, and lack of study in this field give encouragement to examine the features of refurbishment operations in Malaysia [18].

Despite the United Kingdom government's announcement of money for the reconstruction of 50 schools over ten years, from 2010 to 2021, it is standard procedure for builders and designers to go on to the next project without examining how the completed structure works. In United States, the government has granted financial incentives to encourage the refurbishment of existing structures [19]. Commercial refurbishment, unfortunately, have a long history of adding complexity, risk, and uncertainty to the management of such projects.

Despite that, in Singapore’s construction industry which is one of the developing countries for refurbishment project, the refurbishment also is becoming a key economic driver due to the high number of ageing buildings, limited vacant land for future development, and quick technological developments [19, 13]. These efforts have limitations and even drawbacks, as the time required to finish refurbishment projects is typically longer than the time stipulated in the contract. The important obstacles that found in Singapore include the high premium cost associated with building construction, clients' lack of interest or market demand, as well as the high cost of building procedures. In addition, greater initial costs have been identified as the most significant issues to green development in Singapore.

1.2 The Complexity of Building Refurbishment Projects

Refurbishment projects are inherently riskier than other types of building projects, and they frequently exceed budgets and timelines. The possibility for significant risk identification, the complexity of refurbishment projects rather than new construction, and design-related issues such as late discovery of design information, particularly during the design development stage, are the key contributors to this problem [20,18]. In general, the complexity of a refurbishment project arises mostly during the planning phase, as a result of the difficulties in obtaining particular information for the construction project [20]. Several difficulties contributed to the complexity throughout the implementation phase, including a lack of coordination, a delay in the decision-making process, and fragmentation.

On the other hand, refurbishment projects have distinct characteristics due to the scope of work's complexity, as they are typically risky and complicated, involving existing and unsecured site conditions [21]. Furthermore, another barrier and challenges that occur for refurbishing building projects is the presence of a large number of project variation orders [21]. For instance, client requirements, designer, statutory rule revisions, and a problem on-site environment are all elements that influence design alterations. Meanwhile, accessibility difficulties could also contribute to the complexity rise [22]. This is due to the fact that the most of building refurbishment projects take place inside and on the exterior of an existing structure. In addition, it is because of communication gaps between project organizations, inefficient collaboration, and a lack of knowledge of the nature of complexity, as well as the interdisciplinary aspect of the planning process.

1.3 Risk Management in Building Refurbishment Projects

Risk management is known as the process of identifying and adopting measures to mitigate the impact of risk in construction projects, according to [23]. This risk management standard necessitates substantial planning in order to create a risk management strategy that allows project managers to identify, monitor, and mitigate risks as they arise. The risk management process in refurbishment projects as shown in Figure 1.

The first phase in the risk management process is to identify risks, which involves identifying potential risks involved with a project. Risk management is a method for identifying, analyzing, and responding to project risk that include increasing the likelihood and consequences of good traits while lowering the likelihood and consequences of bad attributes [24]. A project risk is an unforeseen event or condition that could have a positive or negative impact on the project's scope if it occurs. Furthermore, an event that may or may not occur, the likelihood of that occurrence, and the effect of that event occurring are all aspects of risk.

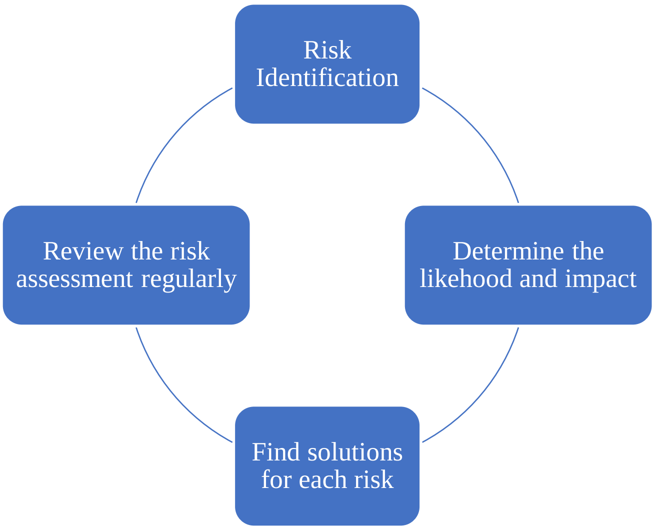

Figure 1. Risk management process [23]

1.4 Building Information Modelling (BIM) Application Strategies

BIM is the method of constructing and managing building data throughout its lifecycle and has shown to be beneficial in most developed countries that have employed it in the construction industry. Despite the fact that many BIM applications are capable of solving difficult construction challenges, BIM technology is still in their early stages of development, and new applications for BIM are continually emerging. This study explored the implementation strategies that have been created and reviews the existing literature on BIM implementation [25]. Furthermore, the traditional risk management approaches have been shown to fail if any dangers are not discovered prior to their occurrence, and BIM can help with early risk detection.

This technology can assist with the development of a virtual project on the computer, as well as the simulation of the construction process, scheduling, and cash flow. In addition, BIM has been proved to be a good technique for improving early detection and assessment of risks in design and construction through 3D visualisation, 4D scheduling, and 5D cost estimation [26]. Some attempts that could integrate better BIM with risk management, such as automatic rule checking and proactive Information Technology (IT) based safety systems, have been noted with the rapid development of BIM in the Architecture, Engineering and Construction (AEC) industry.

Some companies have created software expressly to work within a BIM framework due to the complexity of acquiring appropriate data. BIM helps in the reduction of costs and time, as well as the increase of overall efficiencies [27, 24]. According to study reports, the Malaysian government supports the construction sector to use BIM in their projects since it can help them avoid delays, design conflicts among various professions, and cost overruns. Furthermore, many components of a construction project can benefit from BIM and software. Furthermore, one of the outputs of this procedure is a 3D building model, which digitally represents all properties of the completed object before it is constructed [28, 21].

BIM has taken the AEC world by storm due to the numerous benefits it provides. It is vital to understand that BIM entails much more than the use of specialized construction software. Rather, it is a holistic approach to project planning and design. Construction projects have a shorter lifecycle and are more efficient, which is one of the key benefits of BIM. All aspects of the pre-construction and planning phases become easier to manage and accomplish. BIM also allows contractors to make better material decisions and decreases the chance of human error during the construction process. By improving the planning phase, BIM can help contractors reduce the amount of wasted resources [29].

As a result, cost savings may be realized. Furthermore, by utilizing BIM technology and procedures, companies can lower insurance costs and the likelihood of claims. As a result, BIM is tremendously beneficial in terms of lowering risks and costs. By providing for a better image of the end product, BIM plans provide a more realistic 3D view of the project's final output [29]. This is something that can assist contractors and clients in gaining a better understanding of the final outcome. Besides, it can also assist in gaining a better understanding of the structure and prevent unnecessary rework.

2.0 METHOD

The purpose of the methodological technique is to ensure that the data collected for this study is comprehensive, relevant, and scientifically valid. The quantitative method is used in this study for data collection and involved the collection of numerical data with statistical significance through multiple-choice questions. This method would be sufficient for obtaining the information needed to answer the research objectives. Furthermore, literature review is employed as the first stage of data gathering and followed by design a questionnaire survey, pilot survey and validity and reliability analysis. Furthermore, a self-administered questionnaire with close-ended questions using a five-point Likert Scale in order to rate the appropriate level in the questions from “1 – strongly disagree” to “5 – strongly agree”. Moreover, Likert Scale also allow the respondents to remain impartial in some problems. Despite that, the population in this study are contractor grade 7 (G7) from construction organizations who are registered by CIDB Malaysia is selected based on their experience and knowledge in managing refurbishment projects and involve in BIM implementation within central region areas of Peninsular Malaysia, which are Kuala Lumpur and Selangor areas. The main reasons for selecting contractor G7 are because normally projects tend to be carried out by established large grade construction organizations [30].

2.1 Sampling Selection

The procedure of choosing a sample from the sampling frame using a definite sampling technique. Furthermore, this methodology employs statistical analytic techniques to generate numerical data from which hypotheses may be made, and the findings are trustworthy and can be expended and duplicated across a wide range of populations. In addition, the probability sampling is utilized in order to generalize survey results which each unit has an equal chance of being chosen. Therefore, stratified simple random sampling is selected in quantitative approach in order to help reduce sampling error by offering flexibility in order to prioritize specific strata [31].

2.2 Questionnaire Procedure

A set of questionnaires are designed and structured as close ended questions to give better standardization of response. There are three core sections consisted in the questionnaire. Section A asks about the demographic profile of the respondents to collect the individual information of the respondents. Section B consists with the critical risk of building refurbishment project lifecycle in terms of four distinct phases which are initiation phase, planning phase, execution phase and closing phase. Section C asks about the BIM application strategies. Besides, the questionnaire has been through preliminary tests which consist of validity and reliability analysis to ensure the integrity and durability of information gathering tools when performing analysis.

The content validity is being done by the experts from academicians that involved in construction project management field and construction industry from contractor G7 that involved in building refurbishment project to examine the suitability or relevancy of the indicators in the questionnaire to measure the variable. Meanwhile, coefficient of Cronbach’s alpha is used to examine the reliability of the questionnaire through 30 usable responses from the pilot survey. It is found that the questionnaire coefficient of Cronbach’s alpha is more than 0.7 which is deemed as reliable for quantitative data collection. The results of the analysis showed that all the questions in the questionnaire for each variable are acceptable. Data collected has been analyzed using IBM SPSS Statistical Software which descriptive analysis has been employed in order to achieve the research objective.

3.0 RESULTS AND DISCUSSION

According to the findings from Demographic Profile in Section A, all of the respondents are eligible to answer the questionnaire. Based on the age and working experience, most of them have involved in construction industry for 5 years and above and they are not fresh graduates who lack of experience in construction industry. Furthermore, all of them have an educational qualification of Bachelor Degree, which means they have a higher level of education that gain more knowledge on construction industry. Therefore, the feedback from the targeted respondents is assumed acceptable and applicable to the research findings.

In this research, the critical risk in building refurbishment project lifecycle and BIM application strategies are critically based on the results obtained in descriptive analysis. As a guideline to determine mean score of variables, this study referred to the idea of [28].

3.1 The Level of Critical Risk Based on Building Refurbishment Project Lifecycle

The descriptive analysis is applied in order to achieve the research objective which is to measure the level of critical risk based on building refurbishment project lifecycle. The purpose of analyzing the data is to determine which variables is the most critical risk that occurred throughout the building refurbishment project lifecycle based on the opinion and perception of appropriate respondents. Furthermore, the mean score interpretation of the variables used in this study is interpreted based on the suggestion by [28]. In addition, as rule of thumb, the coefficient of variation for standard deviation is lower than 1 and are considered to be low-variance [29]. Low standard deviation indicates a mean-centered distribution of the data. Data points that are below the mean have a low standard deviation.

Despite that, the independent variable for this study is the critical risk of building refurbishment project lifecycle. The descriptive analysis is conducted by using IBM SPSS Statistical Software. In this study, the independent variables have been categorized into four phases of project lifecycle including initiation phase, planning phase, execution phase, and closing phase. Furthermore, the four phases of the refurbishment project lifecycle have been used to discuss the specific findings of the independent variables. Based on the descriptive analysis's findings, it can be identified that the phase of project lifecycle that has the highest risk due to the highest number of means is initiation phase. This is because the stakeholders can most significantly affect project outcomes at the project's first phases. As a result of the substantial number of unknown factors, risk is highest at this time. Therefore, Table 1 shows the descriptive analysis of means and standard deviation based on each variable for critical risk of building refurbishment project lifecycle.

Table 1. Descriptive analysis for critical risk of building refurbishment project lifecycle

Variables	Mean	Std. Deviation	Findings
Initiation Phase	4.460	0.309	Very high
Cost Projection Risk	4.382	0.407	Very high
Resources Risk	4.489	0.402	Very high
Organizational Risk	4.439	0.453	Very high
Planning Phase	4.376	0.307	Very high
Cost Planning Risk	4.382	0.407	Very high
Design Risk	4.372	0.394	Very high
Project Management Risk	4.374	0.399	Very high
Execution Phase	4.365	0.299	Very high
Existing Structure Risk	4.333	0.426	Very high
Expenses Risk	4.366	0.409	Very high
Operational Risk	4.395	0.420	Very high
Closing Phase	4.408	0.256	Very high
Technical Risk	4.407	0.422	Very high
Safety Risk	4.379	0.423	Very high
Quality Risk	4.438	0.390	Very high

Note: The mean score categorized into five levels: very low=1.00 to 1.80; low=1.81 to 2.60; medium=2.61 to 3.20; high=3.21 to 4.20; and very high=4.21 to 5.00

Based on the result illustrated in the Table 1, it can be concluded that the resources risk is considered as the most critical risk in the initiation phase of project lifecycle due to the highest number of mean values. The reason of the critical risk is due to lack of skilled workers for refurbishment project or dealing with employee attrition at a crucial juncture in the project's lifecycle which can lead to scheduling errors and project delays [30]. In initiation phase, the main risk classification that has been focused in this study consists of three groups: cost projection risk, resources risk, and organizational risk. However, the mean score indicates that the findings of these variables are very high based on the mean score interpretation that used in this study. For standard deviation, the findings value that have been determined towards all the variables are below 1. In addition, the findings for planning phase can be concluded that the cost planning risk is the most critical risk in planning phase due to the highest-ranked of mean value. This is due to project budgets going over budget owing to excess hours worked or delays in fulfilling important milestones. Inadequate funds to cover enough resources required to execute the project successfully [31].

Furthermore, according to the findings in the table, the most critical risk that occurred during execution phase is operational risk. This is because of the poor process implementation and issues with procurement, production, and distribution are the main causes of operational risk [32]. In other words, this project risk is a component of performance risk since the anticipated result does not materialize at all or in the manner anticipated by project managers. Based on the findings of descriptive analysis, it can be determined that technical risk is the most critical risk during closing phase. This is because unpredictability and uncontrolled functioning of technological systems are the main sources of technical risks. Besides, the risk that the system of interest's design and manufacturing will change, thereby influencing the degree of performance required to meet stakeholders' expectations and technical specifications [33]. This may involve software defects, hardware malfunctions, or incompatibility problems.

The outcome demonstrated that the resources risk in initiation phase, the cost planning risk in planning phase, operational risk in execution phase, and technical risk in closing phase can be factually considered as the most critical risk in building refurbishment project. Thus, the findings that attained the high-ranked of mean indicated that the variables are critical in this study.

3.2 The Level of Building Information Modelling (BIM) Application Strategies Based on Building Refurbishment Project Lifecycle

The descriptive analysis is applied in order to achieve the research objective which is to measure the level of BIM application strategies based on building refurbishment project lifecycle. The purpose of data analysis for dependent variable is to identify which BIM application strategies is the most significant in managing the critical risk in refurbishment project and to rank the important level of identified BIM application strategies based on their mean values. The BIM application strategies are determined based on eight different aspects in order to identify which aspect is the most significant in managing the critical risk in refurbishment project. The mean and standard deviation for dependent variable is discussed based on descriptive analysis that has been conducted by using IBM SPSS Statistical Software. There are eight variables that have been measured in this study which are cost, management, design, structural, operational, technical, safety, and quality. In addition, the dependent variable in this study is BIM application strategies. However, the level of BIM application strategies based on building refurbishment project has been measured. Therefore, Table 2 below shows the descriptive analysis for BIM application strategies.

Table 2. Descriptive analysis for BIM application strategies

Variables	Mean	Std. Deviation	Findings
BIM Application Strategies	4.430	0.198	Very high
Cost	4.451	0.411	Very high
Management	4.395	0.387	Very high
Design	4.395	0.366	Very high
Structural	4.432	0.326	Very high
Operational	4.451	0.356	Very high
Technical	4.441	0.367	Very high
Safety	4.420	0.373	Very high
Quality	4.448	0.340	Very high

Note: The mean score categorized into five levels: very low=1.00 to 1.80; low=1.81 to 2.60; medium=2.61 to 3.20; high=3.21 to 4.20; and very high=4.21 to 5.00

According to the findings in Table 2, the mean and standard deviation of each variable for BIM application strategies has been determined. It can be concluded that the mean score of these variables that applied in this study is considered as very high and the standard deviation for the variables considered lower than 1. Furthermore, the variables that have the highest-ranked of mean for BIM application strategies are cost and operational. BIM application strategies in cost aspect is significant in managing the cost risk because the BIM application such as 5D cost estimation can allow the automatic estimation of critical information [34]. Meanwhile, 4D planning and scheduling can help the team to work on measurement details of the structure to control the related cost. Subsequently, BIM application strategies for operational aspect are significant in managing the operational risk because the BIM application such as 3D BIM coordination helps in reduction of construction material waste. Meanwhile, site utilization planning helps to efficiently generated site usage layout for temporary facilities, and material deliveries for all phases of construction [35].

The outcome demonstrated that BIM application strategies in terms of cost and operational can be factually considered as the most significant and applicable in mitigating the critical risk for building refurbishment project lifecycle improvement.

4.0 CONCLUSION

As summarized, the development of the country's economy depends on the building industry. Construction projects must be completed on schedule; any delays could entail considerable costs that must be avoided. To do this, building progress needs to be periodically assessed to ensure that deadlines and goals are met on schedule. It takes a lot of effort to create a system for tracking progress, without which the project risked becoming unmanageable. The BIM application strategies is regarded as an efficient assessment for facilitate the risk strategies for building refurbishment project lifecycle improvement. The implementation of BIM application software can be an alternative to the conventional construction work progress at site which is in line with the era of digitization construction of the fourth industrial revolution (IR 4.0). Despite that, based on the study's findings, it can be concluded that the result for independent variable is critical in this study and the most critical risk for four phases of project lifecycle has been proved due to the highest-ranked of mean which has been obtained from descriptive analysis by using IBM SPSS Statistical Software. Subsequently, there are two variables that obtained the highest-ranked of mean for BIM application strategies which has been determined from descriptive analysis. Based on the findings obtained, it can be concluded that the result achieved high level of mean interpretation, this means that BIM application strategies is significant to apply for minimizing the critical risk in building refurbishment project. Thus, the aim of this study which is the integration critical risk with BIM application strategies for building refurbishment project lifecycle improvement is achieved.

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