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# EXPECTED IMPACT ON DESIGN DELIVERY RISK IN BIM BASED PROJECT IMPLEMENTATION IN SRI LANKA

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**Abstract**
Building Information Modelling (BIM) is an innovative concept which has been using in the construction industry to increase the productivity by creating object based multi-dimensional parametric models. Though Sri Lankan construction industry is in the kindergarten stage of the BIM implementation, most of the developed countries are getting benefits through BIM. BIM can be adopted to the whole life cycle of the construction project not only for the specific phases. Construction industry is a place where it faces plenty of risks throughout its life cycle. Early stages of every project create more and more uncertainties because most of the decisions are made on early stages. Major construction risks were identified through extensive literature survey. Using that list, identified thirteen design delivery risks to carry out the research. Furthermore, carried out a questionnaire survey by using thirty-one respondents to identify the current design delivery risk rate in Sri Lankan construction industry. Semi structured interviews were carried out by using BIM experts to identified expected impact on design delivery risk after BIM implementation. At the end of the study conclusion is addressed to identify the expected impact on design delivery risk in BIM based project implementation in Sri Lanka.

***Keywords:*** *Building Information Modelling (BIM); Design Delivery Risk; Sri Lanka.*

## 1. Introduction

The Building Information Modelling (BIM) is becoming a very precious topic nowadays because of its specialty. Most of the developed countries in the world tend to use BIM applications to achieve their goals and mainly government highly involves to create a better environment for implementing BIM. BIM can be identified as a new-fangled construction management process which is used as a tool to make object based multidimensional parametric models in the construction projects. Mainly construction sector does not have a simple process. It is a combination of lot of processes from the inception to end. Therefore, ultimate result is affected by each and every processes. Due to that reason BIM adoption for the whole process is not that much easy.

Construction industry is one of the most dynamic and challenging risky businesses. Basically, construction industry has a very poor reputation for managing risks. Hayes, Perry, and Thompson (1986) has viewed that most of the projects have failed to meet deadlines and cost targets. Hillson (2013) defines that risk as the uncertainty that can be measured and uncertainty is a risk that cannot be measured. Risk cannot be eliminated, but it can be minimised, transferred or retained (Burchett, Rao Tummala, & Leung, 1999). If risk is transferred, it should be transferred to the party who can bear it properly. Otherwise it will be affected to the final productivity, performance, quality and the final cost of the project. According to Hayes et al. (1986) risk is a part of all construction work in spite of the size of the project.

Risk Management is taken place where risk should be mitigated or eliminated. It is a system which focuses on recognising, quantifying, and managing all risks disclosed in a project (Flanagan & Norman, 1993). There are so many unsatisfactory consequences that can be arisen in different stages of the projects such as design, construction, and operation. For that situation risk management is a beneficial and proactive process to reduce likelihood of those unsatisfactory consequences (Mills, 2001; Rohaninejad & Bagherpour, 2013). In the construction projects, risk management is a logical systematic way of identifying, analysing and treating risk to achieve the project goals and objectives in proper manner. Risk management can be used as a tool for predicting future as well as making preferable decisions for better future (Smith, 1999). When implementing a process of a project, there should be a proper risk management process which is able to deal with the risk. According to the Kululanga and Kuotcha (2010), comparatively low implementation of formal project risk management methods in practice directly affect to the performance of a project.

Especially in developing countries like Sri Lanka, there are rapid developments in construction sector during last decades. Due to that reason large scale of projects have become widespread, design theories are improving, new project delivery methodologies are being adopted and materials of construction are being found (Bryde, Broquets, & Volm, 2013). All of these things are generated as a result of risk. In response to these problems a new trend is taken place which is called BIM.

In the last few years, BIM has been playing a major role in AEC (Architecture, Engineering, Construction) industry and there is a significant increase of the adoption of BIM to support planning, design, construction, operation and maintenance stages due to the rapid development of computer application (Volk, Stengel, & Schultmann, 2014). BIM is becoming a systematic method as well as a process that is changing the project delivery (Porwal & Hewage, 2013), designing (Liu, 2014) and the communication and organisational management of construction (Hardin, 2011).

BIM can be identified as a modern construction management process, which can create object based multi-dimensional parametric models. Those parametric models are used as a tool for construction project management during their life cycle. To achieve these targets, various tools and methods have been using in the construction industry (Race, 2012). As construction projects are very unique and very complex, it needs more and more high amount of resources. Because of this complicated nature, adoption of BIM is not that much simple.

Applying BIM in to AEC industry can be seen to some extent as a systematic way to handle risk. Most of the projects have applied the BIM into the design and construction phase. Proper collaboration and communication environment of BIM automatically facilitate the early risk identification in construction industry (Dossick & Neff, 2011; Grilo & Jardim Goncalves, 2010). Most of the researchers found that BIM is an advanced tool to manage design errors, quality and the budget of the projects.

## 2. Risk

Various types of definitions can be identified for the term of “risk”. According to Olsson (2008) there is no unitary definition for risk even though risk is widely used in construction industry. Moreover, Rowe (1997 as cited in Taylor & Mbachu, 2014) identified risk as a probability of giving unwanted outcome of an event or activity. Both Royal Society (1991 as cited in Edwards & Bowen, 1998) and CIDB (2004) have viewed that the probability of incidence of an event or activity which give the hostile result on the targets/objectives of the project. Mainly these two definitions are focusing on risk event which create negative influence on the project objectives. Taylor and Mbachu (2014) has viewed a different aspect about this area which create positive outcome of risk events come up with the probability of risk.

According to the Taylor and Mbachu (2014) opportunities and risks are considered as equivalent. Even though, according to the Loosemore, Raftery, Reilly, and Higgon, (2006) it is totally different. It says that the opportunities and risks have their own characteristics if it looks like as same. In generally, most of the definitions clearly state that risk is a term which gives the negative impact on the project.

### 2.1. CONSTRUCTION RISK

The following risk categorisation figure is developed by using direct studies as well as other risk related studies done by Bunni (2009), Kartam and Kartam (1999), Thompson and Perry (1998), Amarasekara (2009), Perera, Rathnayake, Rameezdeen, (2008), Osipova and Eriksson (2013) and Gunathilake and Jayasena (2008).

The research is mainly focused on design delivery risks. Following risk can be identified as most critical design delivery risk in construction industry.

- Design error and omission.
- Design process takes longer than anticipated.

- Stakeholders request late changes.
- Failure to carry out the works in accordance with the contract.
- Defective design.
- Deficiency in drawings and specifications.
- Frequent changes of design by designers.
- Drawings and documentation not issued on time.
- Lack of knowledge, experience and work done in haste.
- Not knowing about the new technological improvements.
- Lack of communication within design team adversarial relationship within the team.
- Failure to account for foreseeable problems.
- Poor constructability and buildability.

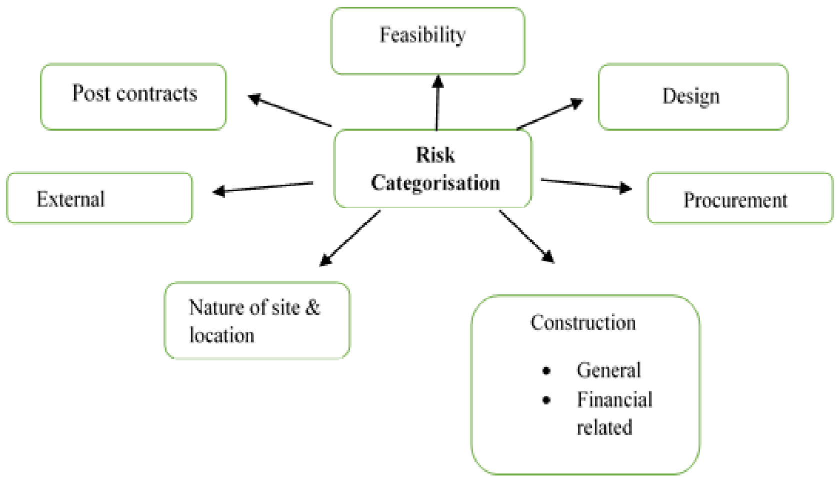


Figure 26: Risk Categorization

## 3. Concept of Building Information Modelling (BIM)

BIM can be identified as a task specific software tool which uses in the initial stage to the end of the life time to generate building data (Deutsch, 2011). To manage the essential building design and projects data, BIM can be involved as a methodology throughout the life cycle (Bilal, 2009).

BIM systems can be identified as software systems which include BIM design applications. Using local area network (LAN) or the internet, system can be connected to each other (Eastman, Teicholz, Sacks, & Liston, 2011). So many data can be produced by using BIM and those data can be used for several uses. Even though AEC industry was showing an objection for the BIM, most of the countries have been getting the advantages of this technology.

### 3.1 BIM EXECUTION PLAN

BIM execution plan is used to imply opportunities and responsibilities of each party who are involving in the project work flow. Basically, following facts should be addressed by the completed BIM Execution Plan;

- Appropriate uses for a BIM on a project.
- Along with a detailed design and documentation of the process for executing BIM throughout a project's lifecycle.

To achieve maximum benefits through BIM implementation, team can follow and always monitor their progress with the plan. Following steps clearly shows the structured procedure for creating and implementing BIM Execution Plan.

- Identify high value BIM uses during project planning, design, construction and operational phases.
- Design the BIM execution process by creating process maps.
- Define the BIM deliverables in the form of information exchanges.
- Develop the infrastructure in the form of contracts, communication procedures, technology and quality control to support the implementation.

## 4. Data Analysis

### 4.1 CONDUCTING QUESTIONNAIRE SURVEY

Questionnaire survey was carried out with 31 professionals in the construction industry, in order to identify the current design delivery risk level in the Sri Lanka. Here, mainly considered about the frequency of occurrence level separately and impact level separately. Further, identified the current risk level and rank them according to the RII value of the risk factors. Microsoft Excel software is used for data analysis and interpretation which is having more benefits as accuracy and time saving. Both RII value of frequency of occurrence and the impact was used to prioritise risk factors. It was easy to refer single RII value rather than considering both RII values at the same time.

### 4.2 SEMI STRUCTURED INTERVIEWS

Questionnaire survey was used to identify the current risk rate in the construction industry as frequency of occurrence level and impact level separately. This method is used to identify whether there is any change in the risk level after adopting BIM in to the process. Furthermore, identified reasons if there were any change due to the BIM implementation. Here, an assumption was made that there is no effect on the impact level from the BIM implementation. That's mean BIM effects on frequency of occurrence level only. At the end it directly change the total risk level even impact level is not changed. Six number of semi structured interviews were carried out to fulfil final objective of the research. Content analysis is a suffuse technique that can be used to analyse qualitative data which give the simple and clear picture about the data. Finally, NVivo version 10.0 which is developed by the QSR (Qualitative Solutions and Research Limited) has selected to generate codes, ability to link.

## 5. Research Findings

### 5.1 QUESTIONNAIRE SURVEY

According to the calculations, mean rate and RII values for frequency of the occurrence can be summarised as follows.

Table 1: mean rate and RII values for frequency of the occurrence

| No | Risk Factor | Frequency of Occurrence-Mean Rate | Frequency of Occurrence - $RII_f$ |
|---|---|---|---|
| **R1** | Frequent changes of design by designers | 4.613 | 0.923 |
| **R2** | Stakeholder request late changes | 4.452 | 0.890 |
| **R3** | Failure to account for foreseeable problems | 4.161 | 0.832 |
| **R4** | Lack of communication within design team adversarial relationship within the team | 4.097 | 0.819 |
| **R5** | Deficiency in drawings and specification | 4.065 | 0.813 |
| **R6** | Design process takes longer than anticipated | 4.000 | 0.800 |

| | | | |
|---|---|---|---|
| R7 | Design error and omission | 3.871 | 0.774 |
| R8 | Lack of knowledge, experience and work done in haste | 3.839 | 0.768 |
| R9 | Drawings and documentation not issued on time | 3.516 | 0.703 |
| R10 | Failure to carry out works in accordance with the contract | 3.516 | 0.703 |
| R11 | Not knowing about the new technological improvements | 3.387 | 0.677 |
| R12 | Defective design | 3.129 | 0.626 |
| R13 | Poor constructability and buildability | 2.968 | 0.594 |

Impact mean rate and RII values were also calculated according to the formula. It can be summarised as follows;

Table 2: Impact mean rate and RII values

| No | Risk Factor | Impact-Mean rate | Impact RIIi |
|---|---|---|---|
| R1 | Design error and omission | 4.839 | 0.968 |
| R2 | Defective design | 4.516 | 0.903 |
| R3 | Deficiency in drawings and specification | 4.387 | 0.877 |
| R4 | Drawings and documentation not issued on time | 4.387 | 0.877 |
| R5 | Failure to account for foreseeable problems | 4.290 | 0.858 |
| R6 | Lack of knowledge, experience and work done in haste | 4.226 | 0.845 |
| R7 | Frequent changes of design by designers | 4.226 | 0.845 |
| R8 | Design process takes longer than anticipated | 4.129 | 0.826 |
| R9 | Failure to carry out works in accordance with the contract | 4.129 | 0.826 |
| R10 | Stakeholder request late changes | 4.097 | 0.819 |
| R11 | Lack of communication within design team adversarial relationship within the team | 4.065 | 0.813 |
| R12 | Poor constructability and buildability | 4.065 | 0.813 |
| R13 | Not knowing about the new technological improvements | 3.419 | 0.684 |

According to the previous calculations, $RII_f$ and $RII_i$ were calculated separately. Risk level for the identified thirteen design delivery risks have been calculated by multiplying $RII_f$ and $RII_i$ values. Following table clearly shows current design delivery risk rate in Sri Lankan construction industry.

Table 3: Current design delivery risk rate in Sri Lanka

| No | Risk | Risk Rate | Rank |
|---|---|---|---|
| 1 | Frequent changes of design by designers | 0.780 | 1 |
| 2 | Design error and omission | 0.749 | 2 |
| 3 | Stakeholder request late changes | 0.729 | 3 |
| 4 | Failure to account for foreseeable problems | 0.714 | 4 |
| 5 | Deficiency in drawings and specification | 0.713 | 5 |

| | | | |
|---|---|---|---|
| 6 | Lack of communication within design team adversarial relationship within the team | 0.666 | 6 |
| 7 | Design process takes longer than anticipated | 0.661 | 7 |
| 8 | Lack of knowledge, experience and work done in haste | 0.649 | 8 |
| 9 | Drawings and documentation not issued on time | 0.617 | 9 |
| 10 | Failure to carry out works in accordance with the contract | 0.581 | 10 |
| 11 | Defective design | 0.565 | 11 |
| 12 | Poor constructability and buildability | 0.482 | 12 |
| 13 | Not knowing about the new technological improvements | 0.463 | 13 |

5.2 SEMI STRUCTURED INTERVIEWS

It is clear that the effect of the BIM implementation can be identified in many ways. Some are directly affected and some are not. Therefore, identifying most suitable and most effective way is the best practice.

Table 4: Impact on risk factor

| No | Risk factor | Risk level will decrease | Risk level will increase | Risk level will not change |
|---|---|---|---|---|
| 1 | Design error and omission | √ | | |
| 2 | Design process takes longer than anticipated | √ | | |
| 3 | Stakeholders request late changes | √ | | |
| 4 | Failure to carry out the works in accordance with the contract | | | √ |
| 5 | Defective design | √ | | |
| 6 | Deficiency in drawings and specifications | | | √ |
| 7 | Frequent changes of design by designers | | | √ |
| 8 | Drawings and documentation not issued on time | | | √ |
| 9 | Not knowing about the new technological improvements | | √ | |
| 10 | Lack of communication within design team adversarial relationship within the team | √ | | |
| 11 | Failure to account for foreseeable problems | √ | | |
| 12 | Poor constructability and buildability | | | √ |
| 13 | Lack of knowledge, experience and work done in haste | | √ | |

## 6. Conclusion

According to the findings of the study it can be concluded that, there is a considerable impact on design delivery risk level after adopting BIM concept. From the analysis, it stated that there are situations like risk level will reduce, risk level will increase, and risk level will not change. All these three decisions were taken based on the opinions of experts who have deep knowledge on BIM. When anlyse the details, an assumption was made that there is no change in RIIi value after adopting BIM into the system. Mainly, when some risk's risk level is not going to change after implementing BIM concept means that risk is not affected by BIM. From the analysis it is identified that there were five risks which are not affected by BIM concept. Those are,

- Deficiency in drawings and specifications.
- Frequent changes of design by designers.
- Drawings and documentation not issued on time.
- Poor constructability and buildability.
- Failure to carry out the works in accordance with the contract

And also, there were six risk factors can be identified as risk which were affected by BIM implementation. Some of the risk's risk level increase and some of the risk's risk level decrease. Following risk can be identified as risk which risk level goes down.

- Design error and omission.
- Design process takes longer than anticipated.
- Stakeholders request late changes.
- Defective design.
- Lack of communication within design team.
- Failure to account foreseeable problems.

Out of thirteen risk factors, there were two risk factors which can be identified as the risk which risk level goes up.

- Not knowing about the new technological improvements
- Lack of knowledge, experience, and work done in haste

Therefore, combining the findings of the research, it can be concluded that there is a considerable impact on design delivery risk in BIM based project implementation in Sri Lanka.

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