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Risk Analysis and Mitigation for Residential Buildings : An Overview

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ABSTRACT: Risks have a major effect on the cost, timeliness, and quality of a construction project. With the increasing scale and complexity of projects, the capacity to manage risks throughout the building process has become a critical component in avoiding unintended effects. The procurement choice and the substance of the associated contract papers have a big influence on how risks are allocated among project participants. As a result, choosing the best project procurement choice is crucial for project players. The main goal of this study is to improve risk management knowledge in the following procurement options: design-bid-build contracts, design-build contracts, and collaborative partnerships. A greater knowledge is anticipated to lead to more effective risk management and, as a result, a better project outcome and value for both clients and contractors. The research is based on nine recent building projects in Sweden and includes a questionnaire survey as well as interviews with clients, contractors, and consultants engaged in the projects. This study's results reveal a lack of an iterative risk management strategy, which is a flaw in existing procurement procedures. If the risk management process is to benefit projects and, by extension, their clients, this element must be addressed. The lack of systematic risk management is most noticeable during the programme phase, when it has the most potential effect. The greatest attention and activity may be seen during the manufacturing phase. In reality, risk communication between players does not always function to the degree that it should if projects are to be delivered with confidence, regardless of the procurement method.

KEYWORDS: Risk management, Risk allocation, Construction project, Construction contract, Design-bid-build, Design-build, Partnering ,

I. INTRODUCTION

Any construction process can be divided into four main phases: programme, design, procurement and production. In the programme phase the client has an idea about the project and analyses conditions for its execution. During the design phase the architects and engineers produce design and construction drawings according to the client's requirements. Depending on the procurement option, the design phase follows either the programme phase or the procurement phase. In the procurement phase the client chooses the contractor and the parties sign the contract. Finally, the contractor executes the job in the production phase. Traditionally, a construction process is sequential; many actors are involved only in some project phases and focus on their own part of work rather than on the whole project. The Construction Cost Delegation (SOU 2000) highlights that an ability to manage the whole process and thus all actors in the value chain is a foundation for change and improvement in the construction industry..

II. LITERATURE SURVEY

Accompanying the identification of risks are recommendations for risk mitigation measures. Recently, a series of measures have been successively proposed to mitigate risks in green building construction projects. For instance, Ranaweera and Crawford [2] proposed a decision-making tool to assess the potential of incorporating environmental strategies into the development of building projects, which may alleviate financial risks caused by sustainable design.

In addition, Hwang, Zhao, See and Zhong [3] recommended a set of special measures to tackle risks in green retrofitting projects, and they highly recommended the following measures, hiring consultants with sufficient experience in managing green building construction projects to mitigate regulatory risk, increasing public awareness of the benefits of green buildings to minimize market risk, using the delivery method of Design & Build to settle communication issues among various contracting parties, and using equipment and materials that have been sufficiently

tested to ensure project quality. Based on the literature review above, this study also compiled a list of 14 measures to mitigate risks in green residential building construction projects. The detailed descriptions are presented in the section of data analysis and discussions.

Zou and Couani [7] stated that risks in green building construction projects could be alleviated by strengthening research and development (R&D), providing professionals with proper training and education, and ensuring coordination and information sharing among various contracting parties. After using their SNA-based risk management model to analyze risks in one green education building construction project in Australia, Yang and Zou [8] found that improving communications and interactions among various contracting parties could effectively mitigate risks in green building construction projects. As an effective instrument to collect data based on a sample, the technique of questionnaire survey has been commonly adopted in green construction management research [7]. Thus, likewise, this study administered a questionnaire survey to assess risks and the relevant mitigation measures in green residential building projects in Singapore. 42 risks and 14 risk mitigation measures obtained from the literature review were utilized to form a questionnaire. Subsequently, two industry experts who had at least five years of experiences in both traditional and green building constructions were invited to review the developed questionnaire, focusing on the statement comprehensiveness, readability, and accuracy. Meanwhile, experts were also encouraged to supplement new risks and mitigation measures based on their practice experiences. Referring to feedback from experts, questionnaire was finalized after a few statements were slightly revised and a set of footnotes were supplemented, as shown in Appendix A. The finalized questionnaire consisted of questions meant (1) to profile respondents and their affiliated companies, (2) to assess the likelihood and impact of each risk in both green and traditional residential building construction projects, and (3) to evaluate the effectiveness of the risk mitigation measures. Moreover, open-ended questions were also positioned in the questionnaire, allowing for any supplement of new risks and mitigation measures.

To ensure the success of a green residential building construction project, a higher level of communication is demanded among the contracting parties as compared with traditional residential building construction projects. This is because green residential building construction projects normally require a multidisciplinary team with a more comprehensive professional composition to handle those complicated and innovative technologies, equipment, and materials adopted in such projects [8]. Any information isolation among team members will probably raise various issues such as rework, delay, and cost overrun.

To mitigate safety risks of LEED certified projects, Fortunato III, Hallowell, Behm and Dewlaney [23] suggested encouraging the use of prefabrication, because prefabrication allowed workers to assemble green-tech equipment indoors, which could spare workers from ascending and descending ladders and lifting components overhead during installation on site and thus minimize the potential safety hazard.

Developing training programs to upgrade workers' skill and knowledge of new technologies and materials" was also assessed as the third most effective measure with a value of 4.20. During constructions of green building projects, one major issue is that frontline workers might be unfamiliar with innovative technologies and materials adopted in such projects [45]. Thus, it is crucial to develop a series of training programs for those frontline workers and make sure that they are well trained and informed of the green technologies they are about to use. Currently, the BCA has rolled out some green courses (e.g., Green Mark Professional course and Green Mark Facilities Professional course) to help the local industry advance their knowledge and capability in undertaking green building construction projects

The method is a non-parametric statistical test to compare two sets of scores that come from the same participants, without requiring the data must be normally distributed [51]. In this study, test results showed that the p-values of 35 risks were less than 0.05, suggesting there were significant differences in RC values of the most risks between green and traditional residential building construction projects. These results meant that the hypothesis of this study, namely, risk criticalities between green and traditional residential building projects were different, was supported. Moreover, the RC values of these 35 risks in green residential building construction projects were statistically greater than those in traditional residential building construction projects, implying that green residential building construction projects are facing risks at a more critical level.

This risk received a high rank in green residential building construction projects (i.e., 6), but a low rank in traditional residential building construction projects (i.e., 32), implying that it was more critical to green residential building construction projects. This might be because, compared to those traditional ones, green residential building construction projects require skilled design professionals to handle specialized green and sustainable designs; while the reality in

Singapore is that competent and experienced local green design professionals are extremely deficient. Furthermore, the Ministry of Manpower of Singapore has recently increased foreigner worker levies and cut quotas of foreign workforces in the construction industry [52], which even aggravated the unavailability of the competent workforce in this regard

III. RESEARCH METHODOLOGY

Research design is about turning research questions into the research project (Robson 2002). It means that in order to answer research questions, the appropriate strategies, methods and techniques should be chosen. The proposes that the types of research questions determine the most suitable strategy. The research questions in this study focus mainly on “what” questions. To answer this type of question, a survey strategy is sdescribe several types of research, e.g. instrumental, descriptive, exploratory, explanatory and interpretive. The research presented in this thesis is of a descriptive type. Descriptive research aims at identifying and recording a phenomenon, process or system and may be conducted using surveys (Fell. Thus, as both references suggest, survey technique was chosen for data collection. The work on the project was divided into two main parts as illustrated in Figure 1.

Step 1- Identification of risk and Risk plays a crucial role in the success of construction project. It is impossible to assess the risks which are not recognized. It is difficult to identify the risks before starting of any project. Therefore firstly sources and types of risk should be identified. However, a complete coverage of the risks is impossible. Therefore to cover the essential risks as completely as possible is the main task of risk management. Step 2- Risk analysis is The main objective of risk analysis is to describe the risk situation precisely and to prioritize the risks. For this purpose the identified risks are investigated with the help of probability of their occurrence and its effect on project in terms of schedule and cost. Criteria must be decided so it will be beneficial for assessing the individual risks and to compare it with another. From the damage or loss in terms of cost and probability of occurrence, a value for risk can be calculated.

Step 3- Risk assessment: Risk assessment involves identification of potential hazard. It comprises the qualitative assessment and quantitative measurement of risks including the interrelationship of their

Construction Project Risk Management. It consist of determination of quantity and quality of risk related to project. With the help of results obtained from risk assessment means by using risk portfolio, the project can be compared with other project. Following methods of risk assessment can be used in construction projects- - Key performance indicators - Qualitative assessment - Probable maximum loss - ABC analysis
- Risk map

Step 4- Risk mitigation:Risk mitigation strategy consist of preparation of risk response plan for minimizing the loss, damage or disruption in project due to risks. Various types of risk responses are described as follows

1. Risk transfer:Project risk can be transferred to someone who is more capable of dealing with it. Such as specialist, subcontractor, designer, material supplier etc.
2. Risk reduction:Risk reduction aims at reducing the probability of occurrence of risk or its impact on the project or a combination of both. Risks can be reduced by well-defined specification, detailed site survey, detailed design, minimizing client variation etc.
3. Risk acceptance:This strategy is commonly used in cases where the probability of risk occurrence is minimum. Mostly this strategy is used in such a cases where consequences are cheaper than the cure. It is used where cost to transfer the risk is high.
4. Risk avoidance:Some risks can be avoided by taking appropriate action such as change in design, by adopting efficient material technology and construction methods.
5. Risk sharing:Taking a risk may be resorted to when it is impractical for one party to control the risk. It may be better to manage such a risk with two or more parties. Alternately the clients retains a part of the risk.

Framework for Construction Industry and Construction Risk Management

Structural Failures and Risk Analysis

The development of various types of infrastructure has been defined as one of the sustainable development goals (SGDs) in the 2030 Agenda for Sustainable Development, which proved the importance of a balance between new

investment in infrastructure and sustainable development. It is necessary to understand the individual SDGs as a collective global development strategy with an international scope, but it must be undertaken primarily at the regional level, hence the importance of construction industry and new investments. It should be kept in mind that the quality of life of inhabitants, both in large agglomerations and in small rural areas, depends to a large extent on the existence of technical, economic and social infrastructure.

Buildings and structures, and various types of infrastructure are therefore important to achieving the SDGs for different main reasons and must meet local needs in a sustainable and environmentally friendly manner. Sustainable development focuses on creating or maintaining natural areas to survive for generations to come; it involves creating added value between different areas, potentially allowing cooperation and the exchange of experiences between other isolated areas, and also underlines the importance of rural areas. Technical infrastructure has been recognized as the main instrument for the implementation of the sustainable development strategy.

In July 2009, the change Az1 was introduced to the standard PN- 77/B-02011. It consisted of the introduction of a new map of Poland's division into wind load zones, new characteristic values of wind speed and pressure of this speed, correction of the exposure factor and increasing the value of the load factor. The roofs of buildings, in addition to their own weight, must bear snow, wind and technological loads. The roof structure and its covering must be designed in such a way as to meet the first limit of state-bearing capacity and use. Constructions work as a whole and its individual parts must be fit for their intended use, with particular regard to the health and safety of those who come into contact with them throughout their life cycle proposed to conduct research on the structural failures in order to improve the life of building objects, but also to consider the need to anticipate, evaluate, prevent, prepare, respond and recover from breakthrough challenges.

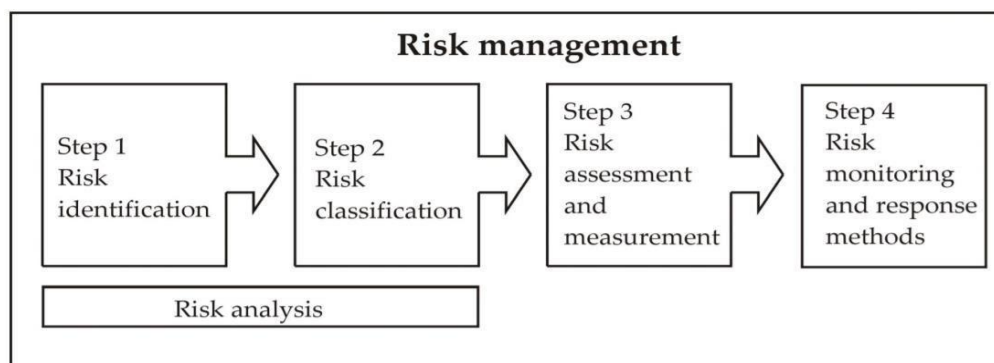


Figure 1 : Risk Management stages

The individual stages of risk management can be used to analyze the risk of the structural failures. These stages were used in this paper as follows:

Step 1. Risk identification—the threats were identified on the basis of the analysis of annual reports of the General Office of Building Control (GUNB). The data were presented on radar charts and analyzed in detail.

Step 2. Hazard classification—classification was made on the basis of the causes of the structural failures. Two main groups were distinguished—disasters caused by random causes (mainly due to the force of nature) and those caused by man (human errors). The failures from the second group (human errors) were classified into three subgroups closely related to the life cycle of a building, namely—design, construction and exploitation

Step 3. Risk assessment and measurement—based on the FMEA method, and more precisely on the determination of the probability of a given threat (P), severity of its result (S), difficulties in its detection (D). These data made it possible to determine the Risk Priority Number (RPN). This number indicates which of the threats (causes) identified in steps 1 and 2 are the most critical from the point of view of the structural failures 1 and 2 are the most critical from the point of view of the structural failures.

Step 4. Risk monitoring and response methods—in the fourth stage, so-called countermeasures (preventive actions), i.e., actions which introduction is aim to reducing the risk of structural failures.

Study is made on the basis of actual case study of residential building. Questionnaire survey has been carried out for the purpose of risk identification. In this report experts are interviewed and response is analysed to form generalized report giving specific idea about the causes affecting most to the company. In this project risks are divided in various categories such as time, quality, project management, contract, people, market, environment, cost etc.

Respondent sheet is form of giving major causes of risk for construction of buildings. These causes were determined as major affecting overall causes to construction industry from previous literature study as well as agreed same by organization.

Respondent sheet is circulated through experts to fill the sheet as per their experience. And finally while taking that risk for the project the average of responses collected has been considered. Respondents are required to fill the response sheet in terms of type of risk (Threat or Opportunity), probability, impact on cost and impact on schedule.

Table 1- Risk matrix criteria

Sr. No.	Probability	Cost	Schedule	Code
1	Very High	Very High	Very High	VH
2	High	High	High	H
3	Medium	Medium	Medium	M
4	Low	Low	Low	L
5	Very Low	Very Low	Very Low	VL

IV. RESULTS AND DISCUSSION

Each risk is ranked as per its occurrence. Rank the probability, cost and schedule from 'Very High to Very Low'.

- Very High: Most chances of occurrence.
- High: Much chances to occur.
- Medium: Frequently occurs.
- Low: Sometimes occurs.
- Very Low: Very rarely (Negligible) occurrence.

For this project we have considered the following parameters with their threshold value for the purpose of risk analysis.

1. Probability criteria-

Table 2- Probability criteria

Code	Name	Range
VH	Very high	>70%
H	High	>50%
M	Medium	>30%
L	Low	>10%
VL	Very low	≤10%
N	Negligible	0

2. Cost criteria-

Table 3- Cost criteria

Code	Name	Range
VH	Very high	>₹250,000
H	High	>₹100,000
M	Medium	>₹50,000
L	Low	>₹10,000
VL	Very low	≤₹10,000
N	Negligible	₹0

3. Schedule criteria-

Table 4: Schedule criteria

Code	Name	Range
VH	Very high	(5 or higher)
H	High	(3 to 5)
M	Medium	(1 to 3)
L	Low	(max. 1 day)
VL	Very low	(in terms of hours)
N	Negligible	0



On the basis of above criteria the responses are filled in response sheet. The average of responses are considered for the project purpose.

V. CONCLUSION

The residential buildings have achieved a rapid development over recent years due to its positive efficacy of saving energy and resources consumptions. However, risks embedded in the construction of green residential buildings are not adequately addressed. Thus, this study conducted an exploratory research to investigate risks and the relevant mitigation measures in green residential building construction projects. Although there have been several studies addressing risks in green building construction projects, very few investigated the risks in green residential building construction projects. Therefore, this study can contribute to the body of knowledge of green buildings. Additionally, findings from this study can also enhance practitioners' awareness of risk management in green residential building construction projects, and thus contribute to the industry.

VI. FUTURE SCOPE

For further research actions, an assessment model that assesses the risk index in green residential building construction projects can be developed. Also, from the risk mitigation measure perspective, an analytical framework of risks in green residential building construction projects can be established so that none of the risks will be ignored when developing relevant risk mitigation measures. Moreover, it would also be very interesting and necessary to do a comparison of risk mitigation measures between green and traditional residential building projects, because this process can help identify unique mitigation measures for green residential building projects.

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Annexure (Questionnaire survey)

Risk Factors	Type (Threats or opportunity)	Probability	Cost	Schedule
Category 1- Time				
1) Logistical risk				
2) Shuttering not completed intime				
3) Rework of any structural member				
4) Re shuttering work				
5) installation of sliding doorsand windows				
6) Delay from steel supplier for material				
Category 2- Quality				
1) Shrinkage, cracks while applying primer				
2) Slab not in level				
3) Lack of monitoring				
4) Shortage of water for curing				
5) Leakage in OHWT				



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