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# A MODEL FOR RISK MANAGEMENT IN BUILDING CONSTRUCTION PROJECTS

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**Abstract-** *Construction Projects are performed in a complex environment that is categorized by risk and uncertainty. The projects fail to achieve their primary objectives due to the absence of an effective risk management system. The status quo of managing risk in construction projects in India is futile. An effective risk management system consists of identification of risks, assessment, response to critical risk and then controls the risk by monitoring. There are various factors which affect the occurrence of these risks. All those risk occur during the project life cycle results in financial loss and even in the stoppage of a particular project. Hence in order to prevent this, proper risk management is very important. The study focuses to establish a Bayesian Belief Network model to improve the time, cost and quality performance of building construction projects. A questionnaire was prepared based on the identified risks and survey was conducted among 140 construction firms. Risk analysis using Probability impact matrix helps in identifying the level of criticality of any risk in construction domain and the model developed establishes relationship of various risks affecting project performance.*

***Keywords-*** *Construction Projects, Risks, Risk Management, Probability impact matrix.*

## I. INTRODUCTION

Risk in Construction needless to mention, with huge money, comes the company of big risks. Construction is a high-risk business, which haunts every participant in the business. Risk management (RM) is the documentation, appraisal and listing of risks followed by synchronized and economical application of resources to minimize, monitor, and control the threats. The objective of RM is to guarantee that vagueness does not glance the effort from the business goals. Figure 1 represents the risk management cycle.

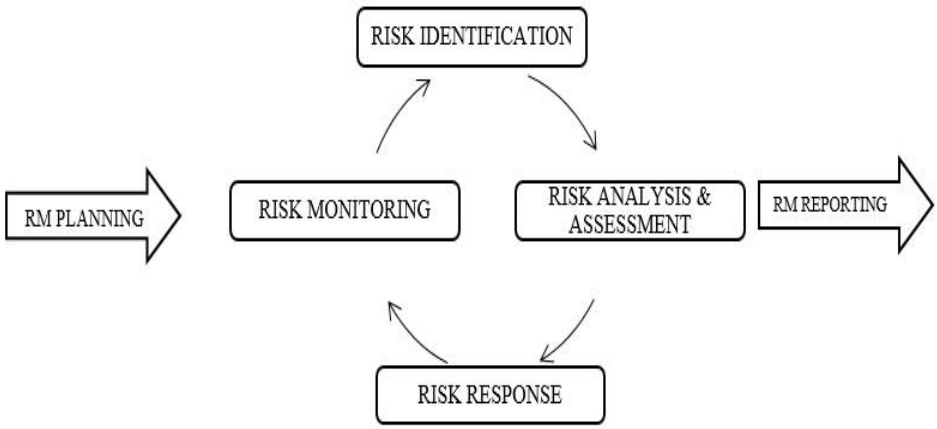


Figure 1. Risk Management Cycle

A broad risk assessment practice is likely to entail of five steps:
1. Documentation of the risk that is to be investigated.
2. A qualitative explanation of the problem and the risk – why it might occur, what you can do to reduce the risk, probability of the occurrence etc.
3. A quantitative investigation of the risk and the allied risk management options that is accessible to determine or to discover a best strategy for monitoring and in that way resolving the problem.
4. Applying the approved risk management approach.
5. Collaborating the decision and its basis to various decision-makers.

 

The study focuses on the issues and uncertainties in various activities of construction projects in the state of Kerala. The construction firms in Kerala lacks a risk management framework and still practices conventional construction process. The research for this study was conducted in private sector construction firms which provides access to present conditions of the construction projects.

**1.1 Objectives**

i To identify risks involved in construction projects.
ii To assess the criticality of risks in project performances.
iii To develop a risk management model for managing risk in building construction projects.

## II. LITERATURE REVIEW

Previous researches suggests that construction industry is more exposed to risks than other business activities because of its convolution. This problem is further enhanced by the unique features of a project and many other external uncertainties. In general, there is an absence of literature that has focused on the practices, results or development of risk assessment and management techniques for Indian construction projects. Odimabo et al. (2013) focussed on risk management for improving the project performance and aims to establish a framework for risk management which will improve the performance of building construction projects in developing countries. The improved performance will be in the form of achieving successful project delivery within the time frame, minimizing cost overruns and optimizing project quality. Renuka et al. (2014) discussed a review of literatures over past 3 decades on identification and assessment of risk factors in construction project. Almost 1000 international projects from various countries like UK, US, Australia, China, Hong Kong, Korea, Turkey, Mexico, Malaysia, Thailand etc. were considered in this study. It mainly focused on the development of models for assessing the risk factors in construction projects. It also discusses the critical risk factors & its contribution in risk assessment techniques. Mahendra et al. (2013) focussed on the general concepts of risk management and the various factors affecting risks was identified and they are: History, Management Stability, Staff expertise and experience, Team Size, Resource Availability, Time Compression and Complexity. Kishan et al. (2014) find out the factors which are responsible for risk in construction projects. Findings are based on literature review, structured interview with construction professionals and present scenario of construction industry. This study was carried out particularly to identify construction project risk and outcome is a list of 47 number of risk factors under the category of Design, Physical, Logistics, Legal, Environmental, Management, Cultural, Financial, Construction and Political risks. Kansal et al. (2012) founded that the currently used methods for risk identification are Brainstorming, checklist, Flowchart Delphi method, Risk significant index method. Mhetre et al. (2016) discussed about the concepts of risk management and various risk analysis techniques to be used for the one stop solution for all types of hazards most likely to occur during any construction project lifecycle. Risk associated with construction industry can be broadly categorized into Technical risks, Construction risks, Physical risks, Organizational risks, Financial risks, Socio-Political risks and Environmental risks.

The literature study reveals that in the last four decades the risk management research has grown considerably in the construction industry. It is observed that construction projects are exposed to risk at the inception stage and are perceived to have more inherent risk due to the involvement of many stakeholders such as owners, contractors and designers, among others. The study has extended to developing countries presenting the need for risk management in construction sector. Developing countries like India stresses on infrastructure development and provide finances for the same in their short term financial plans as the development boosts up the GDP of the country. The vastness of construction projects leaves a lot of scope for unforeseen problems during conceptual phase and execution stage leading to time and cost overruns in projects and compromise in quality. Various researches in this scope provides list of risks involved in the sector which negatively effects project performance. Researches also shows more construction companies are starting to become aware of the Risk Management, but are still not using models and techniques aimed for managing risks and uses conventional method i.e. to wait for the risk to happen.

## III. METHODOLOGY

The system of methods used in the study is shown in Figure 2. The various risks involved in construction projects have been identified through literature survey. Then a questionnaire is prepared with the help of the information gathered during literature review. In the next stage, a questionnaire survey is carried out and critical risks are identified, and then an assessment of the risk as per risk management process is done. Based on the literature review and through expert opinions seven risks prominent in the construction projects are obtained. Then 27 risks are shortlisted under seven sections. Taro Yamane Sample size formula is used for calculating sample size and is calculated as 140. Probability/Impact risk rating is

 

performed based on individual assessment of questions in the questionnaire. The probability of occurrence of each risk is provided in the second section of the questionnaire. For each question the weighted average of the 140 response is calculated to get the average probability of occurrence. Similarly, the weighted average is calculated for all 27 risks. The same procedure is performed to get average degree of impact evaluated in section 3 of questionnaire. The Bayesian belief network was constructed using the Netica version 6.04 and sensitivity analysis is carried out to find the influence of each risks on project performance.

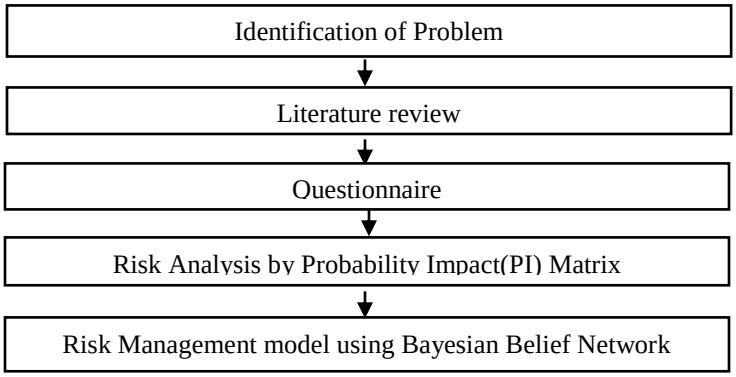


Figure 2. Methodology of the study.

## IV RESULT AND DISCUSSION

An aggregate of 140 responses were collected from construction firms in Kerala and the descriptive analysis of the data were done using SPSS software. The preliminary analysis is done based on Literature Review. The assessment highlights seven major risks: Physical Risk, Construction Risk, Financial Risk, Design Risk, Management Risk, Environmental Risk and Socio Political Risk. Each of these risks are sub-divided into various sub factors.

Physical Risk
- Supply of Defective Materials
- Labour Injuries
- Insecurity and Theft
- Damage to Equipment

Construction Risk
- Labour Disputes
- Non availability of resources
- Availability of camp for labours
- Improper Construction Methods
- Design Changes
- Equipment Failure

Financial Risk
- Delay in Payment
- Fluctuation of Material Prices
- Inaccurate Estimates

Design Risk
- Improper Specifications
- Inadequate Site Investigation
- Improper Planning &Scheduling

Management Risk
- Poor Site Management
- Poor Communication between Involved Parties
- Inexperienced Work Force
- Client-Contractor Disputes

Environmental Risk
- Weather Condition

 

- Pollution by Construction Waste

Socio Political Risk

- Permits and approval delays
- Bribery/Corruption
- Language/Cultural Barrier
- Political Influence
- Change in Laws and regulation

The assessment starts with evaluation of questionnaire survey response. The risks are being analyzed based on two factors which are probability of occurrence and impact. The weighted average of response are computed and tabulated as presented in Table 1.

Table 1. Probability/Impact matrix

| | Probability | Impact | Matrix | Category |
|---|---|---|---|---|
| Supply of Defective Materials | 0.66 | 0.54 | 0.35 | R3 |
| Labour Injuries | 0.20 | 0.20 | 0.04 | R1 |
| Insecurity and Theft | 0.38 | 0.14 | 0.05 | R1 |
| Damage to Equipment | 0.35 | 0.29 | 0.10 | R2 |
| Labour Disputes | 0.46 | 0.22 | 0.10 | R2 |
| Non availability of resources | 0.59 | 0.27 | 0.16 | R2 |
| Availability of camp for labours | 0.50 | 0.34 | 0.17 | R2 |
| Improper Construction Methods | 0.67 | 0.36 | 0.24 | R3 |
| Design Changes | 0.55 | 0.31 | 0.17 | R2 |
| Equipment Failure | 0.52 | 0.21 | 0.11 | R2 |
| Delay in Payment | 0.50 | 0.40 | 0.20 | R3 |
| Fluctuation of Material Prices | 0.53 | 0.39 | 0.21 | R3 |
| Inaccurate Estimates | 0.50 | 0.38 | 0.19 | R3 |
| Inadequate Site Investigation | 0.46 | 0.20 | 0.09 | R2 |
| Improper Specifications | 0.60 | 0.36 | 0.22 | R3 |
| Improper Planning &Scheduling | 0.60 | 0.34 | 0.20 | R3 |
| Inexperienced Work Force | 0.55 | 0.21 | 0.11 | R2 |
| Poor Communication between Involved Parties | 0.53 | 0.28 | 0.15 | R2 |
| Poor Site Management | 0.53 | 0.34 | 0.18 | R3 |
| Client-Contractor Disputes | 0.51 | 0.20 | 0.10 | R2 |
| Weather Condition | 0.46 | 0.13 | 0.06 | R1 |
| Pollution by Construction Waste | 0.27 | 0.14 | 0.04 | R1 |
| Permits and approval delays | 0.53 | 0.23 | 0.12 | R2 |
| Bribery/Corruption | 0.59 | 0.22 | 0.13 | R2 |
| Language/Cultural Barrier | 0.47 | 0.23 | 0.11 | R2 |
| Political Influence | 0.32 | 0.20 | 0.06 | R1 |
| Change in Laws and regulation | 0.35 | 0.19 | 0.06 | R1 |

The risks are then ranked and coloured by comparing with the standards on the Probability/Impact matrix .The Probability-impact matrix shown in table prioritizes risk into three conditions ("Highly critical – Red "Medium – Yellow", "Low – Green"). From the matrix (table), eight risks are found to be highly critical and require risk response/strategies. They are

Supply of Defective Materials, Improper Construction Methods, Delay in Payment, Fluctuation of Material Prices, Inaccurate Estimates, Improper Specifications, Improper Planning and Scheduling and Poor Site Management.

A Bayesian Belief Network (BBN) model for the 27 risks identified was constructed using Netica 6.04 version. The nodes representing 27 risks has three states, R1, R2 and R3 which represents low risk, medium risk and high risk respectively. The relationship between the risks and the project performance parameters (Quality, Time and Cost) was determined using expert opinions and through literature reviews. The risk score obtained from Probability Impact matrix table has been entered in the corresponding risk node for all the risks identified. The model developed is shown in Figure 3. The relationship of various risks can be determined from the model. For example, Poor site management can be determined from the model as follows: Poor site management leads to Non availability of resources which then leads to Improper construction methods, which directly causes quality problems, time and cost overruns. Similarly Client contractor disputes lead to Delay in payment which causes time overrun. Likewise all other risk factors causing quality problems, time overrun and cost overrun can be easily identified from the network model. The values of three states of each risks represents conditional probability which is obtained using Bayes theorem. The conditional probability tables are obtained by using the software Netica 6.04 and these values have significance in finding out the influence of each node on quality problems, time overrun and cost overrun.


Figure 3. BBN model developed using Netica 6.04

Sensitivity analysis is conducted to determine the influence of each risk on performance parameters: Quality, Time and Cost. Higher the entropy reduction, higher will be the influence on performance parameters. Table 2 shows the sensitivity analysis of critical risk factors affecting building construction projects.

 

Table 2. Sensitivity analysis of critical risk factors

| Parameters | Critical risks | Entropy reduction |
|---|---|---|
| Quality problems | Supply of Defective Materials | 0.483 |
| | Improper Construction Methods | 0.516 |
| | Improper Specifications | 0.387 |
| Time overruns | Poor Site Management | 0.491 |
| | Improper Planning &Scheduling | 0.513 |
| | Delay in Payment | 0.410 |
| Cost overruns | Inaccurate Estimates | 0.523 |
| | Fluctuation of Material Prices | 0.456 |
| | Improper Planning &Scheduling | 0.432 |

The risks that are causing Quality issues are: Improper Construction Methods, Supply of Defective Materials and Improper Specifications. Risk factors causing time overruns were: Improper Planning &Scheduling, Poor Site Management and Delay in Payment and finally risk factors causing cost overrun were: Inaccurate Estimates, Fluctuation of Material Prices and Improper Planning & Scheduling. The risks causing quality, time and cost overrun are arranged in the descending order of entropy reduction so that management strategies can be taken to control these risks.

## V. CONCLUSION

The inspiration of this study is the very inadequate application of risk management in construction projects handled by Construction Company. In the first phase of the research work, the problem was clearly identified. The various causes of this issue were analyzed and finally it was found that the construction sector lacks an efficient risk management system. In the second phase, the risk management process has been applied stage by stage starting with risk identification. A semi-structured interview with the technical experts in field was conducted. The on-going project logs, record and historical data in the company had been reviewed. Thus, brief sketch about the various risks which are prominent in the construction projects have been obtained. The following stage is the analysis and assessment of risk. A questionnaire is prepared based on the prominent risk identified, expert opinion and also based on data requirement of assessment. The technique used for analysis and assessment of risk was qualitative analysis. The tool used was Probability Impact matrix rating system. The technique uses standard risk matrix and is compared with risk matrix calculated based on occurrence and impact of prominent risk. The comparison helps to identify critical risk and prioritize risks on the basis of criticality. Then a BBN model has been developed to show the cause and effect relationship of risk factors affecting building performance. The outcomes from this research will assist clients and contractors in construction sector to have a more organized and prescribed approach to risk management. It also helps to make use of their own knowledge and experience as well as best practices in risk management to effectively reduce issues caused by risks in project life cycle and complete the project successfully and efficiently.

### 5.1 Findings

- The study identified 27 prominent risks in seven sectors of construction projects.
- The further assessment identified eight critical risks in building projects.
- A BBN model was developed to show the relationships of 27 risks factors affecting project performance.

### 5.2 Suggestions

- Risk Management introduced to individual large scale projects could help to identify risks in critical activities of the project and plan in advance the strategies to avoid such risks.
- The identification of risk at the initial stage of risk management should be carefully performed so that all the prominent risks should come under study else the rest of the process becomes ineffective.
- Risk management should concentrate more on initial activities of the project life cycle as the research shows critical risks are more related to activities in planning stages.
- For high budgeted and long duration construction projects, risk management should be considered as an integral part of project management.

 

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