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Analysis of Risk Involved in the High-Rise Building of Fast-Track Construction Projects Using Direct Questionnaire Survey and SWOT Method

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Abstract: **-** Implementing massive construction projects with enormous-scale construction and engineering endeavors is dangerous, and assessing the risks associated with those enormous projects is a vital success component. This paper outlines the strategic approach that will be adopted on high-rise buildings for fast-track construction projects for identification, risk evaluation, qualitative and quantitative risk techniques, mitigation and response planning, monitoring and control, communication, liaison, and reporting. To this end, two methods were adopted for the construction of 24 high-rise buildings in Pune, India, using a questionnaire survey and by strengths, weaknesses, opportunities, and threats (SWOT) analysis. A questionnaire survey is done based on the identified risk, and the views of various industrial experts have been taken. The further analysis is done by means of SciPy in Python, and the weightage and ranking of the risk have been found using a correlation matrix.

Keywords*:* Risk Analysis, High-rise building, SWOT, Python, SciPy

1. Introduction

The process of detecting, evaluating, and responding to project risks in order to maximize opportunities and remove obstacles to the project's goals is known as risk management. Risk identification is the first step in risk management, which is then followed by risk analysis, risk prioritizing, and choosing a workable risk management strategy (Sohrabinejad and Rahimi, 2015). Risk management will be tackled in two ways: a) by generating a general awareness of risk within the project organization so that it will be considered within all aspects of the teamwork, b) by an active risk management process, that identifies, assesses and mitigates risks, considers contingency plans and reports the risk to the project. The project management of the construction sector governs the criteria of time, cost and quality. As these are the major project constraints monitoring them becomes a huge task especially when it comes with fast track construction project. The major factor of fast tract construction project is time as these projects have scarcity of time. Monitoring all the tasks keeping the prominent scope of cost time and quality becomes challenging. Identification of the risk is very essential in front end planning of fast-track construction project. In fast-track construction project risk are identified from the very beginning of the start of the project. While there are a number of advantages to the fast-track project delivery strategy, including quicker project completion and lower operating costs, poor planning frequently results in delays, significant scope modifications, and project cost overruns (Aleshin 2001).

These identified risks are then analyzed based on its dependencies on the activities they are linked with. Schedule and cost analysis of these risks has to be done so as to keep the project on track without affecting the critical path of the project. The main aim of this process is to understand the benefits of front end planning for risk assessment of high rise building and to adopt stimulation based approach using Monte Carlo stimulation. There is no universal consensus on the definition of risk but we need to understand what it is before we can measure it, therefore several implicit and problem orientated definitions do exist. Dey (2012) implemented the suggested strategy in a project to build a refinery for petroleum and managed project risk using multiple criteria for making decisions and the decision tree analysis approach. Dey (2010) also created a paradigm for risk management in oil pipeline-building projects based on the risk map and the analytical hierarchy process (AHP). The construction sector is more vulnerable to risk and uncertainty (Kim and Bajaj, 2000; Tah and Car, 2000). This uncertainty stems from the industry's fundamental qualities (Bing et al., 1999). However, the industry doesn't always handle these risks appropriately (Mills, 2001). According to Mills (2001), risk impacts the project's cost, quality, performance, and productivity. Multiple criterions decision-making (MCDM) was employed by Ebrahimnejad et al. (2012) to assess the risk associated with projects of considerable size. They used the model to demonstrate the efficacy of the suggested strategy on a power plant project in Iran (Kimiagari and Keivanpour, 2018).

2. Methodology used in the study

2.1. Risk identification

In the construction sector, fast-track projects are growing more and more common, especially when timeliness is crucial. It is vital first to recognize the advantages and disadvantages of using a fast-track building process to make an educated choice regarding its adoption. Identification of the hazards is crucial to the risk process of management. The identified risks are the one that governs the project management constraints of cost, time and quality. The Identification of the risk here was done through questionnaire survey and SWOT analysis. Total 24 high rise buildings were taken into consideration each having floors in between 19 to 42. The various factors that affect the execution of the work and causes delays were analyzed. Based on the analysis further the risks were categorized into 4 different criteria of contract risks, execution risks, inventory management risks as well as planning and scheduling risks. Based on these for factors a questionnaire survey was prepared. The Identified Risk were categorized in following types on the basis of department: a. contracts department, b. inventory (stores) department, c. planning department, d. scheduling department, and e. onsite construction execution risk.

2.2. Preparation of questionnaire survey

In this research questionnaire survey method was implemented to take feedback from the expert in the construction companies based on the probability of occurrence of the risk. Most of quantitative data is gathered from site visiting, interview and direct observation and work sampling. The present investigation used a variety of avenues for testimony to collect data, including monthly progress reports (monthly), monthly bills (certified), public complaints (report), plan of the project, variation orders, non-conformity reports, claim reports, bill of quantities (BOQ), weather records, letters (if any), interview with one-to-one, as well as archival records like historical weather records (Perera et al., 2009). The questionnaire survey consisted of all the factors affecting the risk in the construction of high rise building. The questionnaire consisted of various factors of risk affecting the time, cost, quality and scope of the work in the construction projects. The identified risk questionnaire was based on the following factors: a. contractual risk, b. execution risk, c. financial risk, d. market risk, e. inventory management and human resource risk, and f. technical risk. The overall questionnaire had around 30 questions. The responses were collected from around 75 industrial experts. The questionnaire survey was based on the probability of 5-point Likert scale. It is one of the typical types of rating scale used to measure attitudes or opinions. With this scale, respondents are asked to rate items on a level of agreement. In this research work we used a 5-point Likert scale based on the probability of risk as rarely, seldom, fair, often, and very often. A risk score is a numerical value that is determined by several criteria and indicates how serious a risk is. Project risk scores are typically determined by multiplying likelihood and effect, while additional variables like weighting may also be taken into account. Risk scores for qualitative risk assessment are typically computed using probability and impact range-based criteria. Distributions of statistical data or independent values can be used as inputs for risk likelihood and effect in risk quantification evaluations.

2.3. Risk probability ranges

Risk probability expresses the likelihood that a specific event may transpire during a project. Here probability is bee categorized into 5 levels: Very Often, Often, Fair, Seldom and Rarely. The problem with these categories is that they can be very ambiguous and have different meanings depending upon whom you ask. To clarify this, we can add additional detail to each probability category so that there is a common understanding i.e. what does rare or very low probability mean? Therefore, it is recommended that each category has a probability definition. In this way, when assessing probability, all team members have a common understanding of the meaning of each category. Based on this percentage response is assigned to each risk for assessing its severity in construction projects. For rarely- 10%, seldom-30%, fair-50%, often-70%, very often-90%

Table 1 Category of risk based on probability

Category of risk	Probabilities
Very Often	71-90%
Often	51-70%
Fair	31-50%
Seldom	11-30%
Rarely	1-10%

2.4. Calculating risk Score

In order to calculate risk score, we need to assign a value to each of the probability and impact levels (e.g. 1, 2, 3, 4, and 5). Now the matrix includes these values for each label. If we had risk that was assessed to have a high probability and medium impact then the risk score = high (4) x medium (3) = 12. Risk scores can then be further defined into categories such as high, medium and low based on the calculated score. On the basis of percentage assigned to probabilities of response, the weightage of the risk was calculated. Based on the calculated weightage the risk was rank. The risk having highest weightage governs the top rank and followed by the remaining. Overall, the first top 12 risk were found for doing the further analysis. Because it permits direct engagement from all stakeholders engaged in the chosen project and improves knowledge of the problem in its natural surroundings (Crowe et al., 2011), a real-world endeavor was chosen for the study. It also provides clarifications and insights into the connections between the obstacles that impact the administration of expedited projects. This study employed three different methods to collect data: a survey completed online, a content evaluation of project documentation, and a summary of previous literature. These techniques are intended to guarantee the consistent collection, analysis, and verification of data (Egbelakin et al., 2021). To find out if sample data matches a pattern of distribution from a particular sample (i.e., a group of people with a normal distribution), one can apply the goodness of fit test. In this paper we have considered total twelve barriers in any high rise building and categorized it by weightage of the risk (Table 2). This gives us insight about the development of the questionnaire.

Table 2 Table representing weightage of each individual risk

Risk Id	Risk Name	Risk Weightage	Mean	Standard deviation	Normalized value	Risk Rank
R_1	Delay in contract award	0.39	0.35	0.17	0.36	7
R_2	Selection of inefficient contractor	0.40	0.42	0.13	0.41	6

R_3	Complex structural design	0.38	0.36	0.15	0.37	8
R_4	Poorly defined scope	0.37	0.34	0.12	0.36	11
R_5	Improper housekeeping	o.46	0.44	0.11	0.45	1
R_6	Absenteeism of labourers	0.45	0.41	0.19	0.42	2
R_7	Lack of material availability according to specifications	0.38	0.35	0.21	0.36	9
R_8	Reworks on site	0.44	0.41	0.13	0.42	4
R_9	Low productivity of equipment and labourers	0.43	0.40	0.18	0.41	5
R_{10}	Delays due to working on heights	0.45	0.41	0.16	0.42	3
R_{11}	Lack of labor safety for working on heights	0.37	0.32	0.12	0.34	10
R_{12}	Poorly sequenced and linked activities	0.36	0.35	0.19	0.33	12

3. Result and Discussions

3.1. Correlation analysis using SciPy in Python

Correlation assessment is a method of statistics for determining the strength of a link amongst two variables that are quantitative. A high correlation indicates that more than one factor are strongly associated, whereas a low correlation indicates that the factors in question are hardly related. In simple terms, it is the act of analyzing the effectiveness of that link using statistical data that is accessible. This methodology is intrinsically linked to the analysis of linear regression, which is a statistical method for simulating the relationship between a variable that is dependent, also known as response, and any number of descriptive or variables that are independent (Franzese and Iuliano 2018). The objective of this paper is to present an in-depth description of the analysis of risk involved in the high-rise building of fast-track construction projects using the direct questionnaire survey and SWOT method. We analyze the correlation coefficient, which informs us how much one variable changes when the other one changes. The existence of a linear connection among the two variables is provided by analysis of correlation.

Interpretation of R in Spearman's rank correlation**:** The Spearman correlation coefficient, R_s can take values from +1 to -1. R_s = +1 gives perfect association, R_s = 0 gives no association R_s = -1 gives perfect negative association between the variables used. The closer R_s is to zero, the weaker the association between the ranks between the variables used. In statistics for Positive Correlations; correlation above 0.75 are considered relatively strong, correlation between 0.45 and 0.75 are considered moderate, and correlation below 0.45 are considered weak. The correlation matrix R, as shown in Figure 1 is the rank correlation between the various risk factors used in this paper for analysis of risk involved in the high rise building of fast track construction projects using SWOT method.

P-Value Correlation Matrix: The correlation matrix P, shown in Figure 2 is the rank correlation between the various risk factors used in this paper for analysis of risk involved in the high rise building of fast track construction projects using questionnaire method. When the null hypothesis assumption is valid, p values ranging from 0 to 1 indicate that there is no association other than chance. A p-value of less than 0.05 is considered significant in statistical terms. A p-value more than 0.05 is not considered statistically significant as it implies that there is insufficient evidence to reject the null hypothesis in any condition or problem.

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Risks	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}
R_1	1	0.39	0.35	0.40	0.42	0.56	0.18	0.47	0.58	0.53	0.46	0.43
R_2		1	0.22	0.39	0.38	0.11	0.39	0.41	0.29	0.45	0.49	0.22
R_3			1	0.42	0.61	0.59	0.36	0.56	0.38	0.55	0.36	0.28
R_4				1	0.54	0.42	0.58	0.65	0.40	0.60	0.38	0.42
R_5					1	0.62	0.48	0.62	0.47	0.60	0.38	0.45
R_6						1	0.36	0.49	0.68	0.59	0.24	0.52
R_7							1	0.62	0.29	0.46	0.24	0.42
R_8								1	0.52	0.65	0.54	0.45
R_9									1	0.61	0.47	0.52
R_{10}										1	0.58	0.52
R_{11}											1	0.40
R_{12}												1

Figure 1. R-Value Matrix for analysis of risk involved in the high rise-building of fast-track construction projects using SWOT method

Risks	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}
R_1	1	0.001	0.003	0.001	0.001	0	0.13	0	0	0	0.001	0.002
R_2		1	0.065	0.001	0.001	0.375	0.001	0.001	0.015	0.001	0	0.065
R_3			1	0.001	0	0	0.002	0	0.001	0	0.002	0.021
R_4				1	0	0.001	0	0	0.001	0	0.001	0.001
R_5					1	0	0	0	0	0	0.001	0
R_6						1	0.002	0	0	0	0.041	0
R_7							1	0	0.014	0.001	0.046	0.001
R_8								1	0	0	0	0.001
R_9									1	0	0	0
R_{10}										1	0	0
R_{11}											1	0.001
R_{12}												1

Figure 2. P-Value Matrix for analysis of risk involved in the high-rise building of fast-track construction projects using questionnaire method

3.2. Correlation Matrix- R Analysis for Categorization of Risk

Based on the analysis of the correlation matrix we categorize the risk into low, medium and high. Risk having correlation co-efficient of 0.5 or more is termed as high risk and have maximum impact with the remaining risks. Similarly, risk having correlation co-efficient in between 0.4 and 0.5 is termed as medium risk whereas; correlation co-efficient less than 0.4 is termed as low risk.

Table 3 Categorization of risks based on correlation co-efficient

Risk Id	Risk Name	Category	Risk Id	Risk Name	Category
R1	Improper House Keeping	High	R8	Complex Structural Design	Low
R2	Absenteeism of Labourers	High	R9	Lack of Material Availability According to Specifications	Low
R3	Delays Due to Working on Heights	High	R10	Lack of Labor Safety for Working on Heights	Low
R4	Reworks on Site	High	R11	Poorly Defined Scope	High
R5	Low Productivity of Equipment and Laborers	Medium	R13	Poorly Sequenced and Linked Activities	Medium
R6	Selection of Inefficient Contractor	High	R8	Complex Structural Design	Low
R7	Delay in Contract Award	Medium			

3.3. Feature importance of variable used

By plotting the feature importance and feature selection plots, it has been found that the P_{12} is the most significant factor to consider when attempting finding the risk involved in the high rise building of fast track construction projects. After the P_{12},, the P_5 is the next most essential factor risk involved in the high rise building of fast track construction projects. Hence, the conclusion for the order of importance of factors could be: $P_{12} > P_5 > P_8 > P_6 > P_1 > P_9 > P_3 > P_2 > P_{10}$ (Fig. 3).

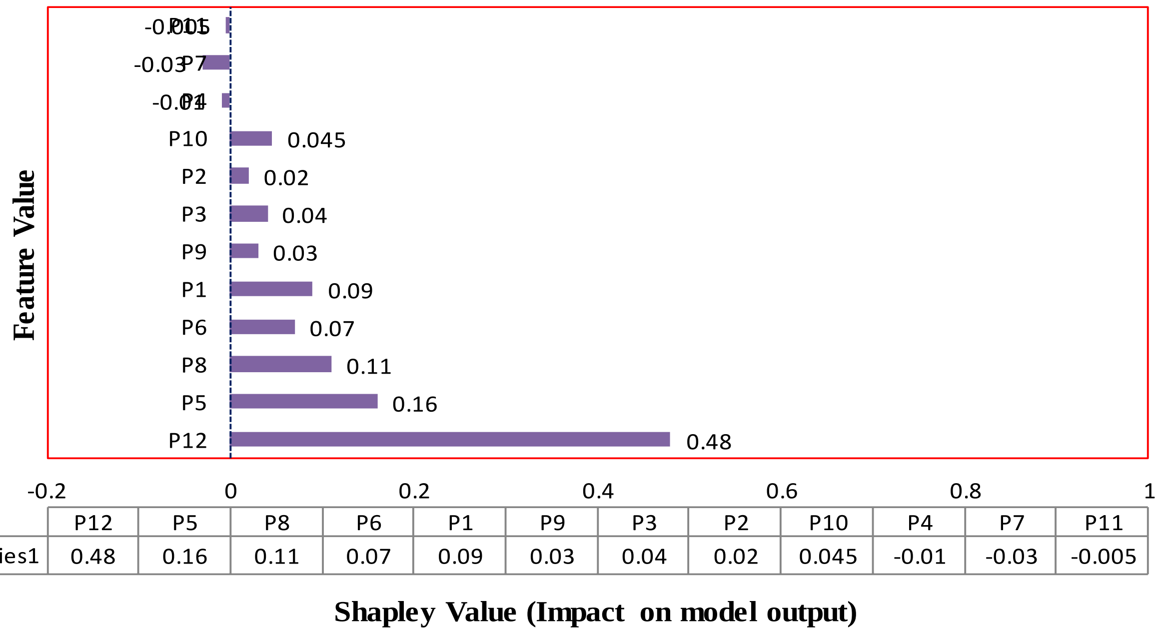

Figure 3 Feature importance plot for all risk IDs using Shapley value

4. Conclusions

Risk management and risk analysis are of prime importance in efficient project management. This research focuses on the correlation analysis of the identified risk from the given case study. Based on this the impact value forum has been generated giving appropriate relevance of the risks and its correlation amongst the rest of the identified risk. For this purpose, based on the data collected via questionnaire survey, weightage of each risk has been found out by goodness of fit. The further analysis is done by using SciPy in Python. Correlation co-efficient between the top risks has been found and the R and P value has been generated. Comparing the R and P value between the risks, it was found that the maximum risk is obtained in case of P value matrix. The risk associated due to direct questionnaire survey in the high rise building of fast track construction projects is too higher compared to SWOT method.

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