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Risk Management In High Rise Construction Projects

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Abstract - *Risk identification and analysis for high-rise construction projects has become the significant part of the present day project management. The development of the area with respect to population and demand always increases the need of greater construction projects with different types of buildings. Currently Ahmedabad city is in one such phase of development where the need of high rise and tall buildings are increasing. With such blooming rise of construction projects the risk management becomes a vital role for the contractors and other stakeholders. Due to the awareness of risk management among the industry experts many risks has been recognized. The top most factors found among the different research papers are socio-economic risk, environmental risk, project management risk, resource risk, labor productivity risk, plant and equipment risk, design related risk, legal problems etc. the research The current research paper focuses on the risks involved in the newly developing high rise construction projects in Ahmedabad city and what risks are involved in the construction. The data collection methodology includes preparation of questioner survey where the risk factors were selected with the help of literatures and discussions and informal meetings with industry experts who are involved in high rise construction. The risk factors are given the scale of likelihood and impact which would be helpful for further data analysis. The results from the questioner survey are analyzed by using various analysis methods. For data analysis qualitative and quantitative approaches are implemented and the severity of the risks are determined. This research paper mainly aims on comparing the results obtained through different analysis methods and to identify the top rated risk factors and the risks which come in common among the different analysis method. The top most risks found in this research cost overrun, inexperienced staff, lack of coordination between agencies, improper project schedule and safety related risks.*

Key Words: **Risk Management, High-Rise Construction, Risk Factors, Cost Overrun**

1. INTRODUCTION

Risk management is the systematic process of analysing, identifying, and responding to projects risk. Construction industry being one of the most complex business it rises the need of risk management. Due to rise of vertical construction from past few decades multi-storied buildings are the most common projects the risk factors increases and the need of risk management becomes necessary. The risks in construction projects are addressed to various factors like environmental risks, geographical risks, socio-economical risks, construction risk, land acquisition risks etc.

Risk identification, analysis and management is a very essential task at planning stage of the construction projects which can led to smooth execution of the project. It is generally found that high rise building are the most important part of the construction industry for the greater development. The major part of the construction industry leads to the high rise building. Hence risk involved in this part also rates higher in the construction industry. Risk management is not a complex task. But if the above steps are followed properly the risks can be decreased to a significant level. The risk management process is bifurcated into four main steps which are risk identification, risk qualification, risk response, risk monitoring and controlling.

1.1 OBJECTIVES

The primary objective of this research paper is to analyze the risk factors associated with the high rise buildings. To evaluate the risk involved in each activity of high rise. The secondary objective is to measure the severity and rank the probability of the most likely risks in the construction process. To compare the relationship between the different variables of data collected

1.2 NEED OF STUDY

Risk management is a very crucial process that is essential to be carried out to control the outcomes of a project and for a smooth execution. With the increasing rate of high rise projects from the past 5 years in Ahmedabad city in Gujarat state risk management becomes more important. The majority of current high rise building projects in Ahmadabad consists of height more than 30 m reaching up to 90 m height. With buildings reaching such range of heights the no. of risk factors becomes high and risk management becomes top priority.

1.3 RESEARCH METHODOLOGY

For data collection qualitative approach is adopted where risk factors are selected by discussions and informal meetings and past research papers. For risk factors appropriate research papers were reviewed. From the selected risk factors risks from each activity are bifurcated into the selected risk factors. Questioner is prepared in google forms and the responses are taken according to the sample size decided. For analysis of data qualitative and quantitative methods are used.

2. LITERATURE REVIEW

Studying the past research papers gives an overview of the past work and the researches carried out on the topic selected which helps in deciding the scope of work. In past research papers, the authors mainly focuses on the hazards involved in high-rise construction projects. Various number of methods are used by the authors for data analysis of risk factors selected. By referring such research papers many benefits are obtained to researchers and industry experts.

3. DATA COLLECTION

3.1 Introduction

Harmony Harikesh Apartments is a luxurious modern flats located at science city sola Ahmedabad. It is a 3BHK and 4 BHK flats with 3 blocks and 3 basements and is the first tallest residential of Gujarat with 32 floors with area of 15000 sq. m. below table 1: shows the details of the high rise buildings.

Table -1: Project Description

PROJECT NAME:	HARMONY HARIKESH APARTMENTS
PROJECT TYPE:	RESIDENTIAL
CONTRACTOR:	RIGID CONSTRUCTION
CLIENT:	MAHAPRABHU DEVELOPERS
LOCATION:	SOLA SCIENCE CITY, AHMEDABAD
FSI:	5
AREA	11,594 SQ.M
NO OF BLOCKS.	3
NO OF FLOORS	32

Figure 1- Site Location

Figure 2- Site Photo Of Harmony Harikesh Apartments

3.2 Questionnaire Design

All the major hazards are selected with the help of literature review and discussions and informal interview with the site experts. The risks are bifurcated into 10 main factors. For the questioner pattern format the risks are quantified likelihood, impact and weightage. Likelihood gives the probability of the occurrence of the risk and impact describes the effect of the particular risk on the project. The weightage gives the multiply value of the likelihood and impact value. The risks are ranked from 1 to 5 scale ranking from very low to very high.

3.3 Sample size calculation

Following is the Cochran formula equation used for sample size collection which determines the number of responses to be taken for the questioner survey which is calculated as following:

$$n_{0} = \frac{z^2 pq}{e^2}$$

Equation 1- Cocheren formula

Here z is confidence level which is taken as 95%
P stands for population size which is 0.5
e stands for correction error 12%
The result for above values are as following:
$= (1.96)^2 * (0.5)* (1- 0.5)/ (0.12)^2$
$=0.9604/0.0144$
$=66.69$ say 66
The sample size is 67

Table -2: Risk Factors

Risk factors	Likelihood	impact	Weightage
Contractual risk			
Organizational risk			
Design risk			
Resource risk			
Project management risk			
Environmental risk			
Socio-economic risk			
Plant and equipment risk			
Financial risk			
Safety related risk			

4. DATA ANALYSIS

4.1 Introduction

The analysis of 10 major risk factors are analyzed. The 10 major risks selected in high rise construction are 1) contractual risk, 2) organizational risk, 3) design risk, 4) resource risk, 5) project management risk, 6) environmental risk, 7) socio-economic risk, 8) plant and equipment risk, 9) financial risk, 10) safety related risk. Analysis is done by both qualitative and quantitative method. Qualitative analysis is done by risk matrix method while quantitative analysis is done by risk severity analysis and probabilistic analysis.

4.2 Probabilistic analysis

Probability can defined as the possibility of an event occurring, while the outcomes of how the event affects the project is the impact of the risk. According to the responses gained by the questioner survey the risks are ranked according to their possibility of occurrence. A graph is generated by the results gained where the most likely risk which has the highest probability is plotted first and likewise all the risks are ranked respectively. The below graph named probabilistic analysis shows the risks selected in a descending order i.e. from the highest risk to the lowest risk. This graph helps in knowing the top most risk factors involved from the selected risk factors. Chart 1 shows probabilistic analysis where the risk factors are ranked on the basis of the highest factor to lowest factor.

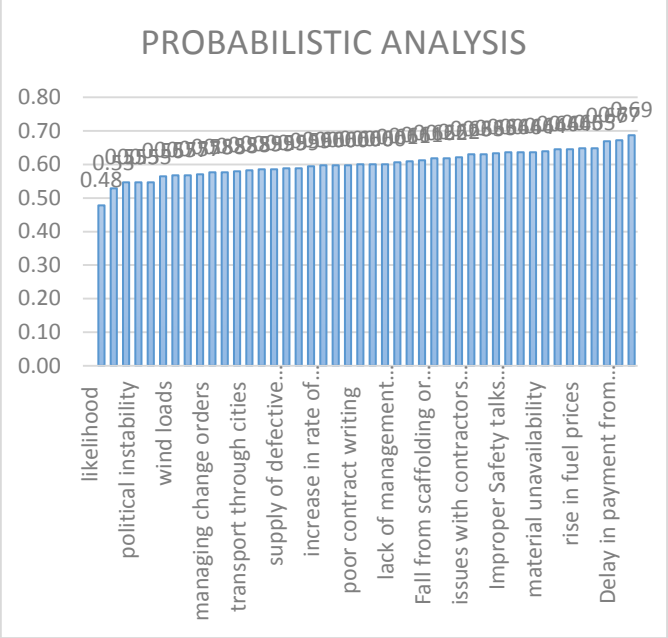

Chart- 1: Probabilistic Analysis

4.3 Risk severity analysis

To determine the risk of the activity risk severity analysis method is used which is explained below:

L stands for likelihood of the activity,
I stands for impact of the activity,
W stands for weightage of the activity,
CLF stands for composite likelihood factor of the activity,
CIF stands for the composite impact factor of the activity.

Likelihood (L): The probability number must be between 0 and 1. The likelihood is the occurrence probability of an activity and is determined by the results obtained from the questioner survey.

Impact (I): The impact number must between 0 and 1. The impact can be explained as the effect of the risk on cost and time of the project or an activity.

Weightage: (W): the weightage can vary according to the local priority (LP), where all sub- activities of a given activity have a weight of 1. On the other hand. The weight

can be varied according to the global priority (GP), where all project activities have a weight of 1.

Composite likelihood factors (CLF): the CLF can be determined by the multiplication of weightages of the risk to their respective likelihoods i.e. (CLF = L*W)

Composite impact factor (CIF): the CLF can be determined by the multiplication of weightages of the risk to their respective impact i.e. (CLF = I*W)

Risk severity analysis can be used with the concept of CLF and CIF. The severity of the risk can be obtained by the product value of likelihood and impact. Table 3 describes the severity classification where the severity is classified from 0 to 1. Table 4 describes the factors divided according to the severity classification

Table -3: severity classification

Severity	classification
0.00-0.20	Very low
0.21-0.31	low
0.32-0.40	medium
0.41- 0.44	high
0.45-1.00	Very high

Table -4: severity classification

Very high (0.45-1.00)	Inexperienced staff Lack of managers on construction site Lack of coordination between agencies Complex designs Design cost overrun Material unavailability Improper project schedule Delay in payment to vendors and sub-contractors Delay in payment from clients Cost overrun Improper safety talks and training to labors Falling of heavy objects Pumping and placing concrete at extreme heights
High (0.41-0.44)	Selection of contract type Poor contract writing Design error and omission Design process takes time that processed Defective designs Selection of materials Supply of defective materials Issues with contractors and suppliers Rise in fuel prices Unavailability of skilled operators Financial instability of clients Improper use of PPE Inadequate traffic marshals and safety personals deployed during execution of work Improper monthly machinery and equipment checks Fall from scaffolding or platforms
Medium (0.32-0.40)	Labor disputes and strikes Technology changes Managing change orders Lack of management software use Adverse climate conditions Earth quake zones Wind loads Increase in rate of interests Wars Political instability Procurement of specialized Equipment Transport through cities Unavailability of spare parts Improper placing of materials

	Change in policies
Low (0.21-0.31)	Risk in exchange of foreign money
Very low (0.00-0.20)	

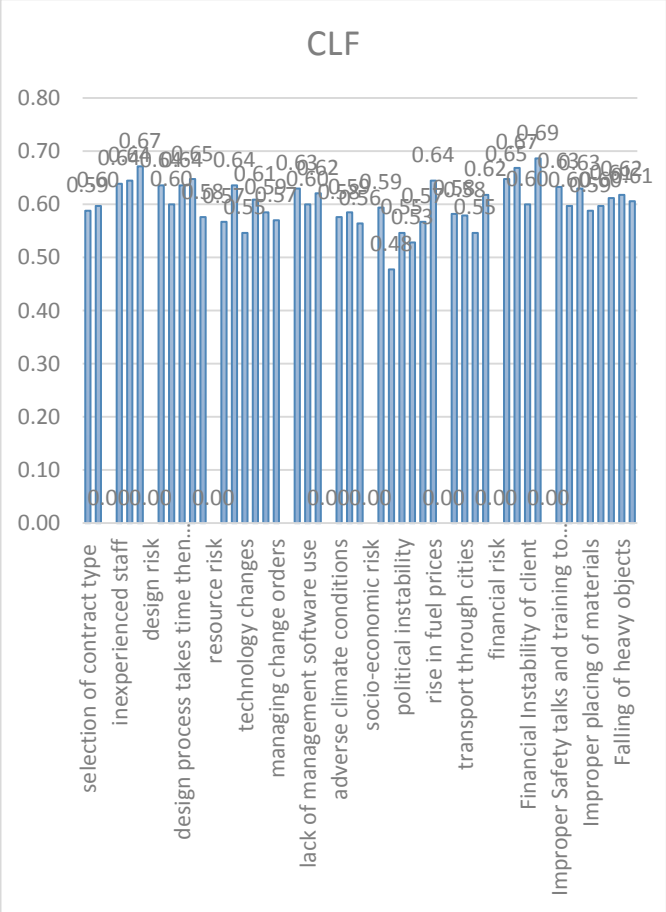

Chart- 2: Composite Likelihood Factor

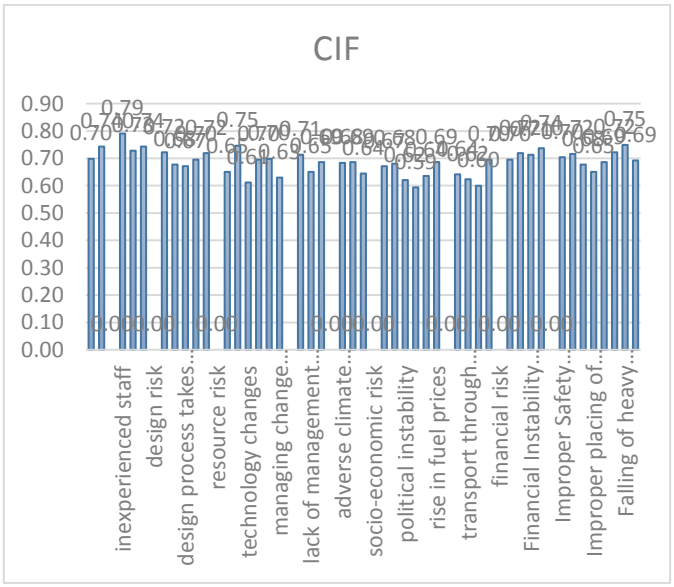

Chart- 3: Composite Impact Factor

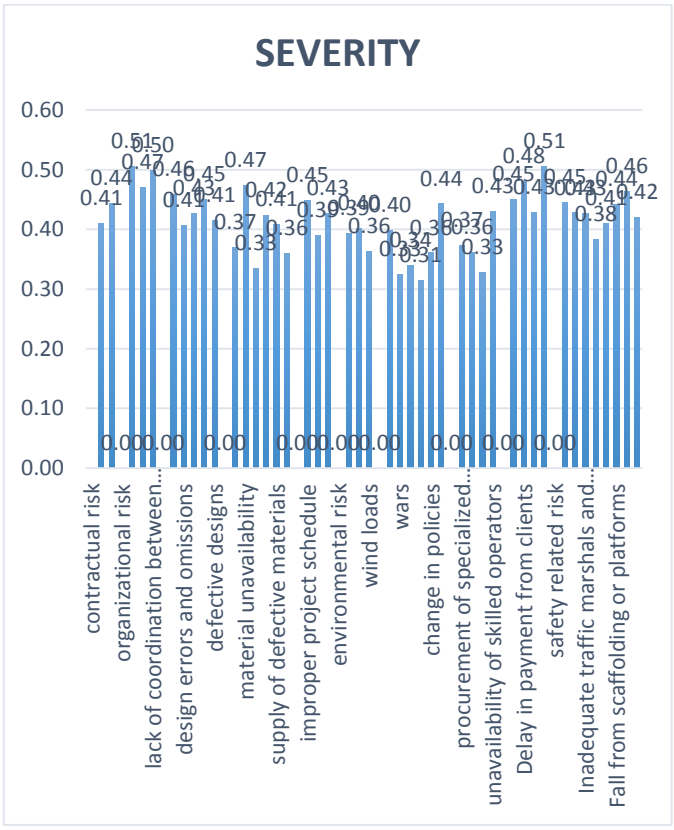

Chart- 4: Severity

Table -5: risk severity

Description	Composite Likelihood Factor (CLF)	Composite Impact Factor (CIF)	Severity (CLF x CIF)
selection of contract type	0.59	0.70	0.41
Poor contract writing	0.60	0.74	0.44
inexperienced staff	0.64	0.79	0.51
lack of managers on a construction site	0.64	0.73	0.47
lack of coordination between agencies	0.67	0.74	0.50
Complex designs	0.64	0.72	0.46
design errors and omissions	0.60	0.68	0.41
design process takes time then calculated	0.64	0.67	0.43
Design cost overrun	0.65	0.70	0.45
defective designs	0.58	0.72	0.41
labor disputes and strikes	0.57	0.65	0.37
material unavailability	0.64	0.75	0.47
technology changes	0.55	0.61	0.33
Selection of materials	0.61	0.70	0.42
supply of defective materials	0.59	0.70	0.41
managing change orders	0.57	0.63	0.36
improper project schedule	0.63	0.71	0.45
lack of management software use	0.60	0.65	0.39
issues with contractors and suppliers	0.62	0.69	0.43
adverse climate conditions	0.58	0.68	0.39
earth quake zones	0.59	0.69	0.40
wind loads	0.56	0,64	0.36
increase in rate of interests	0.59	0.67	0.40
wars	0.48	0.68	0.33
political instability	0.55	0.62	0.34
rise in exchange of foreign money	0.53	0.59	0.31
change in policies	0.57	0.64	0.36
rise in fuel prices	0.64	0.69	0.44
procurement of specialized equipment	0.58	0.64	0.37
transport through cities	0.58	0.62	0.36
unavailability of spare parts	0.55	0.60	0.33
unavailability of skilled operators	0.62	0.70	0.43
Delay in payment to vendors/ subcontractors	0.65	0.70	0.45
Delay in payment from clients	0.67	0.72	0,48
Financial Instability of client	0.60	0.71	0.43
Cost overrun	0.69	0.74	0.51
Improper Safety talks and training to labors	0.63	0.70	0.45
Improper use of PPE	0.60	0.72	0.43
Inadequate traffic marshals and safety personnel deployed during execution of work	0.63	0.68	0.43
Improper placing of materials	0.59	0.65	0.38
Improper monthly machinery and equipment checks	0.60	0.69	0.41
Fall from scaffolding or platforms	0.61	0.72	0.44

Falling of heavy objects	0.62	0.75	0.46
Pumping and placing concrete at extreme heights	0.61	0.69	0.42

4.4 Risk matrix analysis

Risk matrix is an analysis method used to obtain the level of risk on the basis of severity which is obtained by the product value of likelihood and impact. It is useful in risk assessment and to determine the transparency of the risk which gives an appropriate base line for judgments and decision.

Table -6: risk matrix table:

	insignificant	minor	moderate	significant	severe
Very high				Inexperienced staff Selection of contract type	Design cost overrun Improper project schedule Cost overrun Pumping and placing of concrete at extreme heights
High			Material unavailability Delay in payment to vendors and subcontractors Delay in payment from clients Defective designs Supply of defective materials Improper safety talks and training to labors	Lack of managers on construction site Lack of coordination between agencies Complex designs Falling of heavy objects Poor contract writing Unavailability of skilled operators Improper use of PPE Lack of management software use Risk in exchange of foreign money	Financial instability of client Inadequate traffic marshals and safety personals deployed during execution of work Fall from scaffolding or platform
Medium		Selection of materials Issues with contractors and suppliers	Design errors and omissions Design process takes time than processed Technology changes Managing change orders Increase in rate of	Rise in fuel prices Change in policies Adverse climate conditions Earthquake zones Wind loads	

			interests Political instability Procurement of specialized equipment Transport through cities Unavailability of spare parts		
Low		Improper placing of materials		Improper monthly machinery and equipment check Labor disputes and strikes	wars
Very low					

5. CONCLUSIONS

In this research work the data collection was done by quantitative approach where the questioner survey includes 10 major risk factors of high rise buildings. The risks considered are 1) contractual risk, 2) organizational risk, 3)design risk, 4)resource risk, 5) project management risk, 6)environmental risk, 7)socio-economic risk, 8)plant and equipment risk, 9)financial risk, 10)safety related risk. The risk factors are taken from contractor's point of view as to what kind of risks are involved in construction projects for a contractor. The risks of each activity is bifurcated into the 10 major risks. From the responses obtained from the google forms the calculations are made and from the results obtained the analysis is done by both qualitative and quantitative method. Mainly three methods are used for analysis which is probabilistic method, severity method and risk matrix. The results from this methods are explained in below points. For quantitative approach probabilistic method is used where the risk factors are ranked from the most likely factor to least likely factor.

Cost overrun, lack of coordination between agencies, delay in payment to vendors/subcontractors, rise in fuel prices, lack of managers on a construction site are the top five risks from the probabilistic analysis method. From the severity analysis method it is concluded that inexperienced staff, lack of managers on construction site, lack of coordination between agencies, complex designs, design cost overrun were the top risks which are in very high scale. For qualitative approach risk matrix method of analysis is used where the top risk resulted into the sever column are design cost overrun, improper project schedule, cost overrun, pumping and placing of concrete at extreme heights, financial instability of client. The top risks resulted in significant column are inexperienced staff, selection of contract type, lack of managers on construction site, lack of coordination between agencies, complex designs and falling of objects. The most repeated factors in all the three analysis method are cost overrun, inexperienced staff, and lack of coordination between agencies, design cost overrun, rise in fuel prices, falling of heavy objects

6. FUTURE SCOPE

In regard of the developing technology and demand the need of high rise buildings has risen and many promising high rise projects of height more than 70 m are expected to take place in the coming decades. With such a blooming rise in the construction sector many new technologies and complex methods will be used which involves many risks in each and every step of the construction process. The risk factors taken in this work would be helpful in recognizing hazards and in the management and planning of the projects by the industry experts and contractors.

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