RISK ANALYSIS AND MITIGATION TECHNIQUES IN HIGH RISE BUILDINGS: A REVIEW

Umesh Ishvarbhai Patel, Dr. J. R. Pitroda
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Construction Engineering and Management Department,
BVM Engineering College, Vallabh Vidyanagar, Gujarat, India
up5322739@gmail.com

Abstract

Risk is an integral aspect of any significant project. Risk is present in every project, whatever its size or industry. No project is entirely risk-free. If threats are not adequately assessed and plans for coping with them are not established, the project will likely lead to failures. One of the greatest building projects which Plays an important part in growth of the country. It is projected that the high- rise (or) multi-story buildings are the most significant part of the architecture for the greater development. The greater part of the building goes up to high towers. Therefore, the risk involved in this section of the construction industry also scores lower. Risks in building projects are considered one of the most common problems with a range of negative effects on building projects. And when the triggers are known can the risks of the building be significantly reduced. This work aimed to analyses the risk evaluation when constructing high-rise buildings.

Keywords: Analysis, Building, Construction, Mitigation, Monitoring and Control, Risk Identification

I. Introduction

Risk management theory has become very common in a lot of enterprises. Many organizations also establish risk management procedures for improving performance, minimizing losses and increasing profits in their projects [1]. Risk incidence on another project is different from that on another project. Similarly, in each The extent of occurrence and effects of a project often vary from project to project. The board finds it difficult to tackle new projects with risks. There is a lack of risk management, sometimes inadequate risk analysis, that can place projects under construction.

Risk: Danger is described as an explanation of the consequences of uncertainty. Danger is typically referred to as an unwanted event which can be described and quantified by its effect and occurrence possibility. The classical risk definition states that, Risk = Probability x Impact; A probability of occurrence of that event.

Risk Assessment: Risk Assessment is the process by which the identified risks are assessed and eligible for those risks. Increasing risk will be assessed for its probability of occurrence and its effect on scheduling, expense, scope and performance / quality. This will combine probability and affect the overall magnitude of the risk is determined.

A. Need of Study

There are very different standard storied buildings and high-rise buildings. Thus, the tasks involved starting from the planning stage will have an impact on project execution. It will include sustainable infrastructure development around the building. Detailed planning for the building services and facilities at all construction phase will be required. The safety standards increase drastically, the management requirement all.

Other factors that favor this are:

1. Exponentially rising urban population, raising demand for high-rise housing.
2. The human factors are neglected, at the expense of quality of life.
3. Fixing new research goals in this specific field.
4. The new information about high-rise buildings must be accessible to the professionals. Above points justify considering the management of high-rise buildings as different from ordinary.

B. Objectives of Study

Following are the objectives of conducting this study.

Determine the most effective methodology for high-rise development by analyzing, evaluating, and determining the best way to manage the project along with cost efficiency.

Only when their cause is identified can the construction risks be mitigated.

This study was aimed at research the risk assessment when constructing high-rise buildings. About the equipment used only to fight the fire.

II. Literature Review

Following are the literature review based on Risk management and mitigation strategies in high rise buildings and its effects.

According to **V.Sakthinivedithaet al. (2003)** concluded that Building projects are one of the most important projects which play a vital role in the country's development. It is estimated that for the greater development, the high-rise (or) multi-story buildings are the most essential part of the construction.The larger part of the building leads to high-rise towers. Hence the risk involved in this part of the construction industry also ranks higher. Risks in construction projects are considered one of the most common issues that cause a number of negative effects on the construction projects.Building risks can only be minimized when the cause is known. The aim of this study was to research the risk assessment when constructing high-rise buildings. This study was conducted based on a review of the literature and a questionnaire.The data for this research will be gathered through a detailed survey of questionnaires. The questionnaire consists of two sections and the first section consists of general questions, the second section contains the list of major risks and the sub-risks involved. This work focuses on identifying and assessing the risks in high-rise buildings, and enhancing the risks that occur during building construction. [10]

Ming-chunLuobet al. (2014) found that High-rise building risk analysis is of critical importance as there is still a lack of a systematically efficient extinguishing Method to ensure safe evacuation. A case study for a super-highrise building is being conducted to expatiate the procedure and methodology for fire risk assessment of super-high-rise buildings. This paper quantifies both the likelihood of the fires and their effect.[8]

R Kathiravan et al. (2014) managed risks in Building projects have been recognized as a very important management process for achieving Timing, cost , efficiency, safety and environmental

sustainability goals for the project. Project Risk Control in the past few years has been the topic of intense discussion. The goal of this paper is to identify and analyse the risks from project participants and life cycle perspectives and their impact on time and cost associated with the development of construction projects in terms of human safety. This can be done by calculating the lab productivity rate and by analysing the work force's company's objectives. [9]

E.R. Gokul Surjith (2014) integrated thatBridge construction projects are initiated with complex and competitive problems resulting in high complexity and risk circumstances intensified by time- and cost constraints.Their work aims to identify and evaluate the risk factors that influence bridge project performance as a whole through use of appropriate methods and techniques, and to develop a risk management process.[4]

AratiChougule (2015) identified theTechnological risks, building risks, socio-political risk, risk to the community, risk to the management. Risk is an important part of any single project. Risk is present in every project regardless of its size or industry.No project is completely risk-free. The project is likely to lead to failures if threats are not adequately assessed and plans are not built to deal with them. The data were gathered with sufficient knowledge from seasoned staff In the construction sector. The object of this review is to identify critical factors affecting the construction projects and their correlation. This paper presents the factors with the highest likelihood and/or effect that statistics on any project and correlation between them. [2]

Hanish Verma et al.(2017) concluded thatHigh-rise structures, which have the potential to ease congestion urban sprawl, are also called 'vertical cities.'Indian cities experience massive growth in population as a result of population growth from nearby villages, resulting in urban sprawl, demand for housing, rise in land costs.Housing grew into a sector-generating economy. Construction projects are one of the most important which plays a vital role in the country's growth. It is projected that for the greater growth, the high-rise (or) multi-storey buildings are the most important part of the design.Given this demand, although high-rise residential structures in the metropolitan cities have become a solution, they remain eluded in India's Tier II cities. High density dwelling styles in these cities have grown to be low-rise or mid-rise. Only when their triggers are established will the building hazards be minimised.The aim of this study was to research the risk assessment when constructing high-rise buildings. This study was conducted based on a analysis of the literature and a questionnaire. The bulk of high-rise buildings always exist as plans.In this case study, an investigation shows The high elevation buildings are not preferred because of the consumer's perception of fire danger and high construction costs. The techniques used in this study will help to identify risks. [5]

ImayantiBasari (2017) Increasing space and limited land requirements are causing numerous high-rise construction projects in Indonesia, particularly in big cities. Building projects and high-rise construction projects are situated in large and varied environments contributing to high rates of complexity and danger. Building project uncertainties are often present and also contribute to delays or cost failures. In a number of companies, the concept of risk management is becoming very popular. Most organizations also develop risk management processes for enhancing efficiency, reducing losses and growing profitability in their ventures. Danger occurrence on another project is different from that on another project. [6]

Leenu Paul (2018) Risk management is an instrument for defining and managing certain risks in a project And with adequate care. This study's methodology depends on the questionnaire survey that was gathered from the local high-rise construction contractors. pilot study and interviews are conducted to identify the risk factors which affect the construction industry 's efficiency. A total of 24 risk affecting factors in three divisions are identified through pilot study and from expert advice. The risk management and assessment can be improved by combining qualitative and quantitative methodologies to analyse the risks.[7]

Ahsan Nawazet al. (2019)conclude that Building is an extremely dangerous business that lacks a good reputation for risk management. But as a result of increased rivalry and construction activities This gradually gives it more meaning. The research indicates that, in the sense of locality Low- level risk control was applied. The findings also indicate that there is a greater degree of correlation between positive risk management and project efficiency. The results demonstrate the importance of risk management techniques, their use, involvement and effect on the performance of the contractor's construction projects point of view, thus encouraging the main project participants to use risk management. [1]

Pitroda et al. (2019) given Information on Identification of risk factors and expectations of Indian construction professionals, i.e. contractors, owners, project managers and engineers, on the importance of different construction risks and how the risks should be shared among contracting parties. Risk management is the approach that covers evaluation risk analysis with the aid of responding qualitatively and quantitatively with the appropriate management and control technique. The term has acquired prominence in various industries. The system is also used in different companies for improving their output in their ventures to reduce their losses and improve their profits.The questionnaire sample is evaluated with the use of the Relative Importance Index (RII) tool for customers, contractors, engineers and architects.We concentrated on understanding Risk management system for construction projects and offering in-depth information on the use of risk management in high-rise building projects. [3]

III. Risk Management

A. Risk Management Processes

Risk management is the structured mechanism by which possible project threats are identified, evaluated and reacted. It involves optimizing The probability and impact of positive events, and the risk and effects of negative events on project goals are that. Each section defines the project risk management process. Risk management will be discussed in two ways as follows:

Creating a General risk perception within the project organization such that it is taken into account in All Teamwork areas.

Defining, assessing and mitigating risks, considering contingency plans and reporting the risk to the project using an active risk management protocol.

The Processes for Risk Management include:

1) Risk recognition – define and assess which risks may affect the goals of the project and record the characteristics thereof;
2) Qualitative risk assessment-perform a qualitative risk assessment to determine its effect on project objectives;
3) Quantitative risk assessment — Measure the likelihood and effect of risks and calculate their impact on project goals;
4) Risk Management Preparation — Designing strategies and methods to reduce risks to project goals;
5) Hazard management and control — Surveillance of residual risks, identifying possible hazards, taking measures to minimize the probability of occurrence and impact of each danger, and assessing the effectiveness of the hazards interventions over the lifecycle of a project.

The Risk Management process should be conducted to track and manage the probability and effect of project risks.

a. Risk Identification

Based on previous experience (implant training), expert opinion (literature review) and expert assessment, the risk recognition strategies are as follows:

a) Technical Risks
b) Environmental risk
c) Financial risk
d) Socio-political risk
e) Construction Risks
f) Management risks

b. Risk identification Techniques

Risk Identification can be done by the following methods:

1) Brain storming: It is one of the most sought-after methods. It's usually used for producing ideas; it's also very useful for detecting threats. All relevant project-related persons meet at a single location. There is one facilitator who briefs with the participants on different issues and then takes note of the variables. The facilitator checks the variables before closing it exclude the unwanted ones.
2) Delphi technique: Strategically thinking about HRM allows a company to look beyond the here and to understand the external and long-term factors that are likely to impact its business over the coming years. There are six main characteristics of a strategic HRM strategy that include a structure of SHRM formulation criteria and we're addressing them in relation to the construction below.
3) Interview /expert opinion: Experts or workers with ample project expertise may be of great help in consistently avoiding / resolving similar problems. All project participants or related individuals may be interviewed for the identification of risk-influencing factors.
4) Past experience: The analogy for the identification of the factors can be built from previous experience with the same kind of project. When comparing project characteristics, insight will be provided on the common factors. Check lists: These are predetermined basic yet very useful lists of variables that are possible for the project. The checklist, which includes a list of the risks found in previous projects and the responses to those risks, offers a head start in the identification of risks.
5) Check lists: These are basic yet quite useful, predetermined list of possible factors for the project. The checklist, which includes a list of the risks found in previous projects and the responses to those risks, offers a head start in the identification of risks.

c. Risk Assessment Procedure

1) Identify the hazards
    a. Walk around the workplace;
    b. Look at the work habits, location, equipment used, substance exposure;
    c. Speak to staff, administrators and students;
    d. Consider recent accidents/incidents.
2) Including board of directors, staff, teachers, young people, guests, vendors, cleaners, new mothers and expectants.
3) Evaluate the risks

When managing risks, a systemic approach should be used to determine which control measure to enforce, taking into account the general control hierarchy as follows

a. Elimination: The danger is built or mechanized.
b. Substitution: Use the less hazardous material / substance.
c. Engineering controls: Install ventilation systems, fixed guarding systems, sound fittings.
d. Signs, Warnings and administrative controls: Install detectors, safety protocols, barriers, checks, access controls.
e. Personal Protective Equipment: Hearing security, protective glasses, face masks, gloves.

4) Report and enforce your findings:

a. Document evaluation on the College risk assessment form.
b. Archive Reports on Connected.
c. Ensure that any further steps needed are completed and the assessment is updated accordingly.
d. Communicate reports to employees and any other person(s) influenced by the work activities.

5). Review Assessment

Assessments should be assessed every 2 years, or sooner, if the assessment is suspected of no longer being accurate.

d. Risk Analysis

Risk analysis, the next step in the risk management process, explores the causes and consequences of risk management the accidents that cause harm.

The purpose behind such an analysis is a precise and unbiased assessment of the risk. Risk analysis seeks to try and capture all possible options and to determine the various consequences of each decision.

Based on the answers obtained from different respondents to the questionnaire, the study was carried out using the Social Science Statistical Kit to assess the percentage of each risk.

B. Benefits of Risk Management

1. Risk management leads to a deeper understanding of and prevention of potential effects resulting from unmanaged risks.
2. The benefit of collaborating with risk management is greater control of the entire project and more efficient methods of problem solving.
3. There's better quality data for decision making
4. It's easier to spot projects in trouble

IV. Risk Mitigation

Mitigation: The purpose of mitigation is to reduce the risk and/or effect of a danger to below an acceptable level. Early intervention to avoid a danger is more successful than attempting to rectify the aftermath after it occurs. Considering the possible effect and likelihood of the risk, mitigation costs should be reasonable.

It is the last method of risk management which includes the application of risk response to the risk. To ensure they are successful, all responses to risks have to be monitored and reviewed.

Risk responses should also be reported thoroughly for future reference and appropriate updating of project plans. Because of the possibility all necessary changes in schedule, budget etc. should be reported and modified in the project plans. Risk management should be a continuous process where the risk impact is calculated and assessed again.

Risk Monitoring & Control: Risk monitoring and control tracks known threats, measures residual risks and detects new risks – ensuring that risk strategies are followed and measuring their efficacy in risk mitigation.

Risk monitoring and control is a process that continues for the life of the project. Following on from Fig.1. And Ill.2. Displayed criticality of work at such heights and its protective steps for staff.

Fig. 1. Working at heights

Fig. 2. Prevent fall from height

V. Case Study

Case Study 1

This case study is on occurrences of Risk management of ventures at high-rise buildings in Saudi Arabia.

Locaion: SAUDI ARABIA

General: Risk management preparation is the method of deciding how a project will be handled and risk management activities planned. Planning for the resulting risk management processes is necessary to ensure that risk management level, type, and visibility are proportionate to Risk as well as value of every project.

The main risk management goals as described by a risk strategy are:

a. Identifying a baseline risk level in a project;

b. Use of common risk management practices throughout a project;

c. Determining, evaluating and determining a project's risk with respect to its probability of occurrence and impact, e.g. time, expense, scope and quality / performance.

Data Analysis by Relative Important Index (RII) Method

Data collected from the survey questionnaire were analysed with use of the Relative Importance Index method to rank each factor from an engineer, architect, contractor and owner perspective.Table 1 shows the ranking of overall response by RII method for risk factors.

TABLE 1. RANKING OF OVERALL RESPONSE BY RII METHOD FOR RISK FACTORS

ID	Factors	RII	Rank
A	**Design**		
A1	Defective Design	0.705	6
A2	Awarding the Design to Inexperience Designer	0.675	11
A3	Inaccurate Quantities	0.657	15
A4	Design Changes	0.673	12
B	**Physical**		
B1	Occurrence of Accidents Because Of Poor Safety Procedures	0.649	18
B2	Supplies of Defective Materials	0.625	22
B3	Security of Material and Equipment	0.596	29
B4	Varied Labour and Equipment Productivity	0.652	16
C	**Logistics**		
C1	Improper Site Investigation	0.636	21
C2	High Competition in Bids	0.712	5
C3	Poor Communications Between the Site and Head Offices	0.689	9
D	**Legal**		
D1	Ambiguity of Work Legislations	0.327	35
D2	Difficulty to Get Permits	0.586	31
D3	Disputes Among the Parties of Contract	0.625	22
E	**Environmental**		
E1	Adverse Weather Conditions	0.622	25
E2	Difficulty to Access the Site	0.689	10
E3	Natural Calamities (Floods, Earthquakes, Fire, etc.)	0.723	4
F	**Management**		
F1	Poor Communication Between Involved Parties	0.689	8
F2	Improper Planning	0.692	7
F3	Changes in Management Ways	0.651	17

F4	Information Unavailability	0.617	26
F5	Material Management	0.746	3
F6	Equipment Management	0.668	13
G	**Cultural**		
G1	Religion	0.222	38
H	**Financial**		
H1	Delayed Payments on Contract	0.779	2
H2	Unmanaged Cash Flow	0.591	30
H3	Inflation	0.485	33
H4	Financial Failure of the Contractor	0.791	1
I	**Construction**		
I1	Gaps Between the Implementation and the Specifications.	0.638	20
I2	Actual Quantities Differ from the Contract Quantities	0.361	34
I3	Lower Work Quality in Presence of Time Constraints	0.604	28
I4	Undocumented Change Work Orders	0.662	14

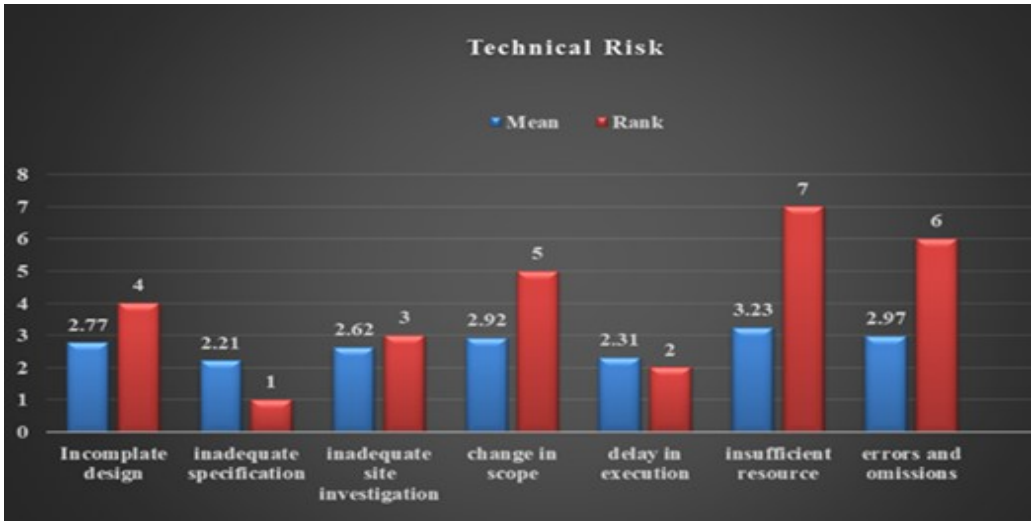

Fig. 3. Technical risk factors

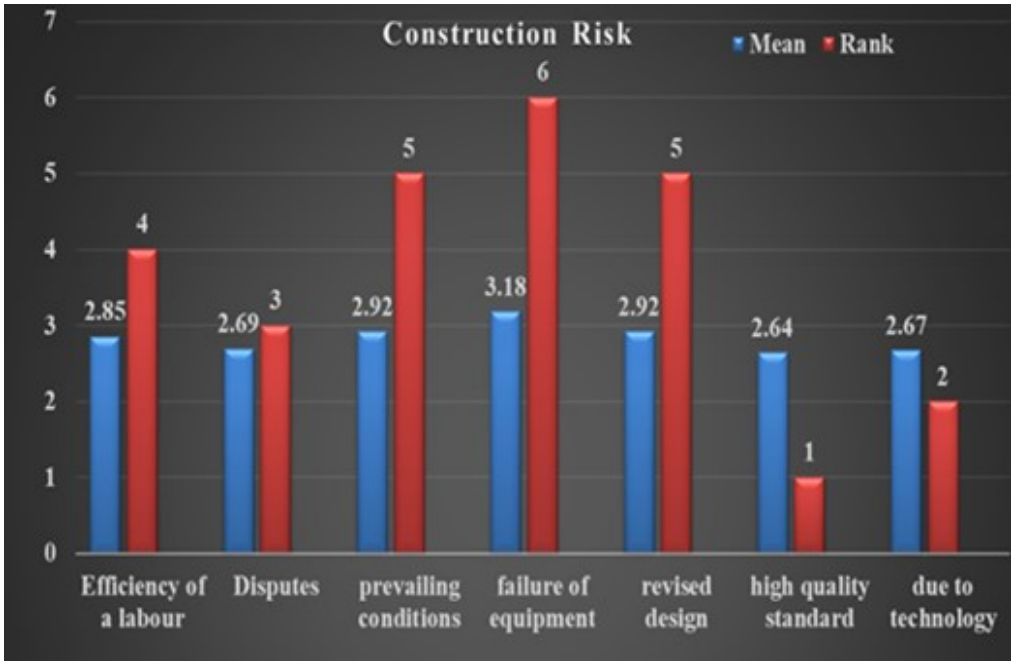

Fig. 4. Construction risk factors

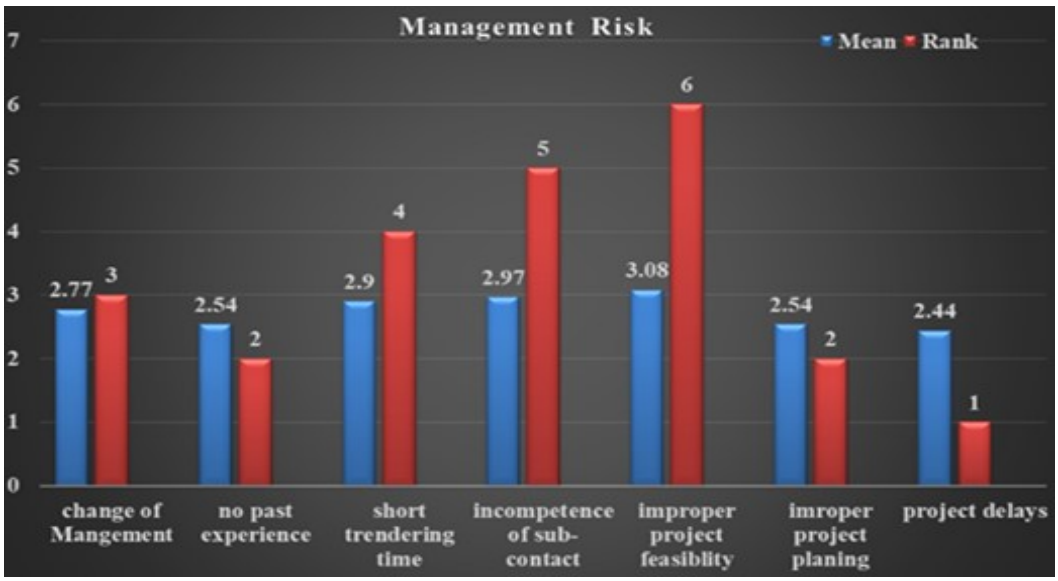

Fig. 5. Management risk factors

As above fig. 3,4,5 is shown risk factors of technical, construction and management field respectively with their mean and rank as per surveyor's survey.

Result: The top five risk factors affecting high-rise construction projects are described below, taking into account all responses.,

1) The contractor 's financial loss to the interest of RII = 0.791

2) RII-value material management = 0.746;

3) Natural calamities have a RII value = 0.723

4) High bidding competition with the value 'RII = 0.712

Case Study 2

This Case Study on Risk Inentification and Assessment In Construction of High rise Building in kerala

Location: kerala, india

Factors Influencing Risk

Risks associated with the construction industry can be broadly categorized into:

Table- 1: List of risk influencing factors

External Risks	Project Risks	Internal Risks
Union issues	Obsolete technology & Tools	Type of contract
Bribery & Corruption	Knowledge on equipment	Delay in license and permits
Fluctuation of raw material prices	Designing errors	Cost overruns
Scarcity of materials	Non availability of resources	Environmental regulations procedure
Shortage of labors	Labor accidents	Differing site conditions
Unpredicted weather conditions	Defective work/Rework	Late changes in design

Results And Discussions

Risk factors on the construction projects are divided into three groups: External, Project and Internal. The following graphs show the impact of risks in high-rise building construction.

Chart-1: Impact of external risk factors

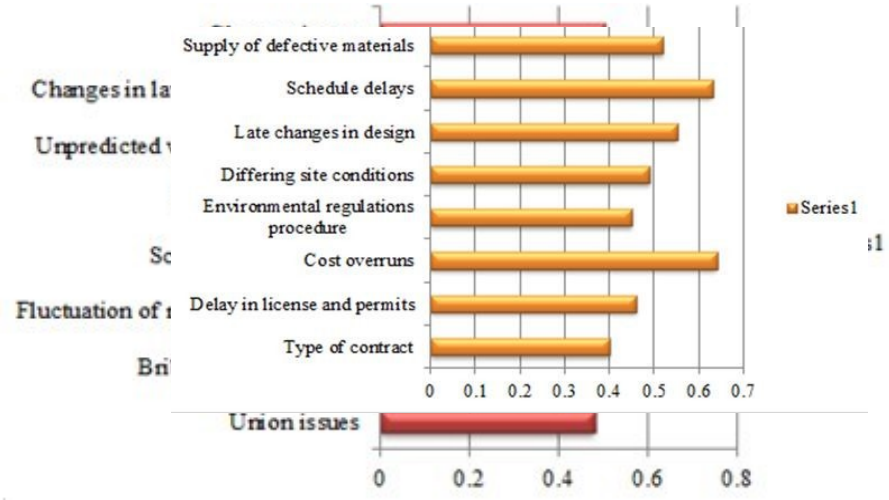

Chart-2: Impact of project risk factor

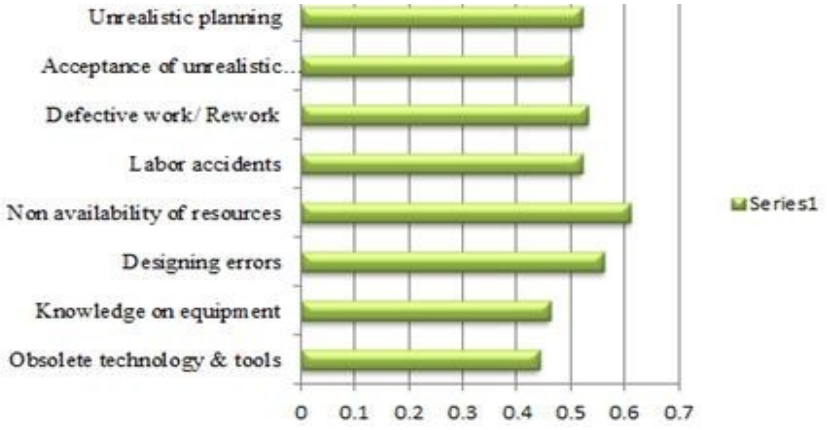

Chart-3: Impact of internal risk factors

Scarcity of materials, Non availability of materials and cost overrun are the high impact risk factors in external, project and internal risks respectively whereas bribery and corruption, obsolete technology and tools, Type of contract are the factors having less impact in external, project and internal risks respectively.

Risk Mitigation

The Project Manager determine appropriate metrics for the project,ensuring they are not burdensome and do not affect behaviour. Results of the analysis need to be communicated and adjustment made through a change management . Comparable to risk reduction, risk mitigation takes steps to reduce the negative effects of threats and disasters on business continuity (BC).

VI. Conclusions

1) In order to reduce their effect on Highrise construction projects, engineers should pay special attention to issues related to material handling, inadequate preparation and coordination between the parties involved.
2) Specific consideration should be paid to the issues of faulty construction and coordination between the parties involved by the developers, contractors, in order to reduce the effects on the effect of high-rise building projects.
3) Risk management is an integral part in the process of construction. The correct identification and assessment of risk factors are the critical procedure for the success of the project. A total of 24 risk affecting factors in three divisions are identified through pilot study and from expert advice.
4) Engineers and contractors are urged to pay careful attention to resource control, proper preparation and coordination between the parties concerned.
5) Particular attention should be paid by the owner on issues related to outstanding payments, awarding the design to the inexperience designer, awarding contract to the financially incapable contractor, contact between the parties concerned.

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