Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

RISK ANALYSIS OF PRECAST STRUCTURE OF BRIDGE

S. W. Manjarwal Professor, Civil Engineering Department, Sandip Institute of Technology and ResearchCentre, Nashik, Maharashtra, India- 422213, Savitribai Phule Pune University, Pune.
Corresponding Author's
Bodke Mayuresh Kishor, Matsagar Vishal Vasantrao, Ugale Prasad Sunil UG Students, Civil Engineering Department, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India- 422213, Savitribai Phule Pune University, Pune.

Abstract
India is growing fast with the rapid growth in infrastructure, smart city projects and other commercial and housing projects to satisfy the population. This all things cannot be managed by old time-consuming conventional construction methods. The conventional construction is too lengthy and risky for man and money. It also hinders the quality and cost of project. The new developing era of construction is finding the fastest and smartest solutions for everything. Precast construction is one of the solutions. The precast industry gives fast, accurate and quality construction. Precast also gives safe and healthy environment. People choose precast because it is risk free. But people are not aware that this smart solution also has some risk involved. During this process of precast and prefabricated structures the onsite engineers, workers face a lot of challenges. As a result, the erection and fabrication of this projects become a very difficult to do task. Risk analysis is a very crucial process in all the life cycle of project. Precast- prefabricated structure construction project has complicated structural design, Complexity of work and potential risks in project work. Project risk can obstruct the project activities and achievements. This can affect the cost, scope and time in analyzing precast and prefabricated construction project. To encounter this the objectives the identification the risks of technical and construction management, allocate the risk appropriate parties, namely owner, contractor and shared (owner and contractor) and assign the risk response to dominant risk in the precast and prefabricated project. Identification of risk was conducted through on sight brainstorming with professionals and through literature study and validation of the questionaries' survey the risk analysis base on the result of main survey was carried out using relative index method. The dominant risk was allotted to the contractor, owner and shared stake holders and risk matrix was made.

Keywords: Precast , Risk analysis, Construction management, Healthy environment.

I. Introduction

The construction industry is one of the most dynamic, risky, and challenging businesses. Although many significant projects fail to finish on time and within budget, the sector has a very poor reputation for risk management. Weather changes, labour and plant productivity, and material quality all have a significant impact on this. Risks are way too frequently neglected or handled in an arbitrary manner; a common practise is to simply add 10% contingency to the project's estimated cost. Such a strategy is frequently ineffective in the complex construction industry and can lead to costly delays, legal action, and even bankruptcy. All construction organisations must consider risk management while making decisions. For some building projects, risk and uncertainty may have detrimental effects. Risk can have an impact on a project's productivity, performance, quality, and budget. Although risk cannot be completely removed, it can be reduced, transferred, or kept.

The concept of risk management is not new. In the past, it has been used instinctively, with risks remaining implicit and being controlled by experience-based judgement. The systematic method formally describes the risks, makes them understandable, and makes them easier to handle. In other words, systematic risk management is a management tool, which requires practical experience and training in the use of the techniques.

1.1 Background

Risk analysis is according to Project Management Institute (PMI) one of the nine knowledge areas and the integration of an effective Risk analysis is considered a crucial element and essential for project success (M.M, 2012). Construction projects can be described as tremendously complex projects in which uncertainty might arise from various sources. Risk analysis is therefore increasingly becoming an extensive component of the project management of construction projects in a pursuit to efficiently deal with unexpected events and ambivalence (Atkinson, G.2009). It is important due to the damaging consequences imposed by risk and uncertainty. However, for years the industry has had a poor reputation for managing the adverse effects of change resulting in delays and a failure to meet quality and cost targets (Abrahamson, N. A. 2007).

1.2 Risk Analysis: Risk analysis is a systematic process of identifying, assessing, and evaluatingrisks to understand their likelihood, potential impact, and associated uncertainties. It involves the use of techniques, tools, and methodologies to analyses risks and make informed decisionsabout how to manage or mitigate them effectively.

The key components of risk analysis typically include:

1. Risk Identification 2. Risk Assessment 3. Risk Mitigation or Management

4. Decision-Making

Risk analysis can be performed using various techniques and tools, such as probability analysis, impact assessment, risk matrices.

1.3 Risk Analysis TechniquesQualitative Analysis

Qualitative risk analysis techniques do not operate on numerical data, present result in the form of descriptions, recommendations and ordinal scores, where risk assessments are connected with qualitative description and determination of qualitative scales for the probability and impact of the consequences of risk.

The main qualitative analysis techniques are:

- Brainstorming
- Delphi method
- Cause and affect diagram
- Checklist
- Event Tree Analysis (ETA)
- Risk Breakdown Structure (RBS)

Quantitative Analysis

A quantitative analysis technique, the estimation of risk exposure related to the application of numerical measures. The impact of consequences defined as a monetary value and the likelihood by the frequency of risk occurrence based on past series of available data. In brief, quantitative techniques numerically analyse the effect of identified risks on the project objectives

The main quantitative analysis techniques are:

- Decision Tree Analysis
- Expected Monetary Value (EMV)
- Expert judgement
- Fault Tree Analysis (FTA)
- Fuzzy logic
- Probability distribution

II. Need of Study

Precast Prefabricated construction projects very major part of construction industry which has an important role for growth of the nation. The risk factors in construction projects are very high. Hence risk involved in Precast Prefabricated structures also plays a major role in construction industry. Construction project objectives are always unique and built once. Risks are arising from different

sources. Risk all the time occurs at construction projects and frequently leads to time overruns or cost overruns.

Risk Analysis is the procedure of determining how to approach and organize the risk events for respective projects. Risk Analysis should apply at the initial phase for project development; Risk Analysis will be very useful in developing an understanding of project uncertainty.

Risks are part of activities in the construction industry that adversely affect the project objectives required of time, quality and cost. Some easy risks can be identified in Risk analysis, but some can be unexpected from external factors such as social, political, administrative and environmental factors, and risks may affect the project in terms of time and cost increase on contractors. Current studies focus on understanding Risk analysis, developing Risk analysis practices and literature survey in the construction industry.

III. Problem Statement

Bridges are main and important transportation structures. A bridge is a structure providing passage over an obstacle without closing the way beneath like water, valley, roads and other obstacles. If the construction risk of the bridge is not given more attention, risk accidents that occur during the bridge construction phase will result in significant losses to the owner and construction companies. The worst catastrophic may occur during bridge construction is collapse of permanent or temporary construction. If risk management is not considered in bridge construction projects, there is chance for unwanted problems and uncertainties, by these risks objective cannot be achieved on time, within budget, or with suitable quality results.

IV. Objectives

The major objective of present work is too important in Precast-Prefabricated structure. To improve safety performance in the construction industry which can be done by achieving the following sub-objective

1. To identify and analysis the various type of risk of Precast structure.
2. To carry questionnaire survey base on Precast structure.
3. To analysis the questionnaire survey through Relative Index Method.
4. To analysis of method of erection.
5. To understand the role of Risk Analysis in Precast Structure.
6. To reduce the risk of Failure of structure due to identified risks.

V. Methodology

Fig 3.1: - Flow chart of methodology

VI. Literature Review

1. P. Karthigai Priya (2019) - Author has studied the current situation of construction in India. Most of the construction activities in India take place by conventional cast in situ method of construction. But still there is a huge demand for housing in India. So the construction activity has to take place in a much faster way. This cannot be achieved
by conventional method of construction. It can be done possible with precast concrete of construction. Moreover, there are more advantages of precast concrete when compared with conventional one. So various are studied and a review of those all has been given in this paper. Also, the advantages and disadvantages of precast construction are also discussed here.

2. Goran Cirovic (2019) - The author studied the risks in construction industry. Construction industry is a highly risky process mostly because of its long-life duration and unique product as a result of construction, and also many different professions are involved in one project. Generally, risks in construction industry should be controlled and reduced during design, procurement and construction phase, and the most important activities are defining risk management plan from the very beginning and to assign risks to different project members and to manage their execution. In this paper risks on a project in initial phase will be presented, cost and duration risks and complete contingency for the previously defined budget will be described. Statistical data for one project in design phase will be analyzed and general comments and recommendations will be proposed. Also, general method for calculating risks will be presented.

3. Dziadoaz and Rejment (2015) - studied the three different methods of the risk analysis as well as stress their disadvantages, advantages and primary areas of application. These methods differ in their methodology from each other. Analyse was done using statistical method, which determines the type of used data hence it affects the quality of the results. The result of the paper was to use the method for identification and preliminary assessment of risk by the matrix of risk and develop risk assessment model in construction projects it should be emphasized on the compilation available.

4. Naser and Kodur (2015) discussed the important factor that was used to quantify fire risk in present and new bridges and provide guidelines for designers to tackle the fire hazard in bridges. The degree of vulnerability of structural and sub structural component to fire mainly depend on fire resistance of various structural members of bridge.

5. Neeraj and Balasubramaniyan (2015) studied the key factors of risk in construction industry through questionnaires. Thirty-eight factors influenced risks in construction were analysed through pilot study, which include experts of academicians, government sectors and construction industry were interviewed, and interviewed experts obtained twenty-two evaluation criteria as the key factor. This approach provides a more effective, accurate and organised decision support tool.

6. Parvathy et al, (2015) studied the major risks and risk factors that influence the three classes of the Indian construction companies, which undertake the majority of the projects in the South Indian cities of Cochin and Udupi using Analytic Hierarchical Process (AHP). AHP tool act as multi-attribute decision-making method in which each risk factor and sub-risk each risk factor based on that output. The results help in management of construction companies to identify which type of risk was most likely to occur in a particular class of company, so that it could be mitigated in the future.

7. Kinnaresh Patel (2013) discussed the risks which were identified in two ways for better decision making. Using the work break down structure the level of risk was determined. Through questionnaires survey they collected necessary data. With the help of the brainstorming session questionnaire was prepared. Primavera software was used to analyse the risk. They investigated that financial risks and construction risk were most influenced risk in Indian construction industry.

8. Kansal and Manoj (2012) studied the different methodology of risk identification techniques in the construction industry. The construction industry was specialised into industrial construction, infrastructure and heavy construction. The research carried out through questionnaires survey within the construction industry. Risk significant index method, they had analysed the collected data. A three-point rating scale was chosen to differentiate the risks. Finally, it was identified the current used

methods for risk assessments were Brainstorming, checklist, flowchart, Delphi method, Risk significant index method. Each method of risk assessment has their limitation hence it was observed that risk assessment could be integrated into new approach that helps decision making.

9. Rafiq M. Choudhry, etal. (2014) The key findings of this research are the exploration of critical risk factors affecting project schedule and costs. The relative importance index categorized seven risk categories in descending order, including financial risks, external risks, design risks, management risks, construction risks, contractual risks, and health and safety risks. The research determined that financial risks were the major factor in affecting the costs and schedule of projects. Among the 37 factors, the top five highest ranked risk factors were unavailability of funds, financial failure of contractor,poor site management and supervision, inadequate site investigation, and inadequate project planning.

10. Chau Ngoc Dang, et al. (2017) This study attempted to identify the risk patterns in Vietnamese road and bridge construction. Questionnaire based interviews were employed to extract the actual context and content of risks from road and bridge projects in Vietnam. To collect risk-related data, 48 practitioners working for 33 different contractors were interviewed using a questionnaire which consisted of 51 risk factors. Then, the specific probability and impact of 51 risk factors, which were grouped into contractor related, project-related, owner-related, and external risks, were determined.

VII. Data collection methods (e.g., interviews, surveys, case studies)

Data collection is a crucial part of any research project. In a project on risk analysis in the Precast Prefabricated Bridge construction project, there are several data collection methods that can be used to gather relevant data. The choice of data collection method will depend on the research questions, hypotheses, and the nature of the research project. Here are some data collection methods that can be used:

1) Interviews: Interviews can be used to collect primary data from stakeholders in the Precast Prefabricated Bridge construction project, including project managers, contractors, architects, and engineers. Interviews can be conducted in-person, over the phone, the questions asked in the interview should be designed to elicit specific information related to risk analysis in Precast Prefabricated Bridge construction project.

2) Questionnaires Surveys: Surveys can be used to collect quantitative data from a larger sample of stakeholders in the Precast Prefabricated Bridge construction project. Surveys can be administered online or in-person and can include multiple-choice questions, Likert scales, and open-ended questions. Surveys can be designed to capture information about the perceptions and attitudes of stakeholders towards risk analysis in Precast Prefabricated Bridge construction project.

3) Document analysis: Document analysis can be used to collect data from existing documents related to high-rise construction projects. This can include project plans, risk assessments, incident reports, and other relevant documents. Document analysis can be used to identify trends and patterns related to risk analysis in Precast Prefabricated Bridge construction project.

4) Focus groups: Focus groups can be used to collect qualitative data from a group of stakeholders in the high-rise construction industry. Focus groups can be conducted in-person or online and can be used to explore attitudes, opinions, and experiences related to risk analysis in Precast Prefabricated Bridge construction project

Some other techniques of data analysis:

1. Identify potential risks: Begin by identifying the potential risks associated with precast prefabricated structures. This may include risks related to design, manufacturing, transportation, erection, and usage of the structure. Common risks may include structural failures, material defects, transportation accidents, improper installation, and environmental factors.

2. Assess the likelihood: Determine the likelihood of each identified risk occurring. Consider historical data, expert opinions, industry standards, and any relevant research to estimate the probability of each risk event. Assign a rating or numerical value to represent the likelihood, such as low, medium, or high, or a numerical probability.
3. Evaluate the impact: Assess the potential impact or consequences of each identified risk. Consider factors such as the severity of injuries or damage, financial loss, project delays, reputational damage, and legal implications. Assign a rating or numerical value to represent the impact, such as low, medium, or high, or a numerical scale.
4. Prioritize risks: Analyze the likelihood and impact ratings to prioritize the risks. Focus on risks with high likelihood and high impact, as they pose the greatest potential harm. This prioritization helps allocateresources and attention effectively during risk mitigation and management.
5. Mitigation strategies: Develop and implement risk mitigation strategies for the identified high-priority risks. This may involve modifying the design or manufacturing process, improving quality control measures, implementing safety protocols during transportation and installation, or providing adequate training to the personnel involved. Ensure that the mitigation measures are practical, feasible, and tailored to address the specific risks.
6. Monitor and review: Continuously monitor the effectiveness of the implemented risk mitigation measures. Regularly review the risk analysis to identify any new risks that may arise during the project lifecycle. Update and adapt the risk management strategies as necessary to ensure the ongoing safety and success of the precast prefabricated structure.
7. Documentation and communication: Maintain detailed documentation of the risk analysis process, including identified risks, their likelihood and impact assessments, mitigation measures, and monitoring results. Clearly communicate the identified risks and their management strategies to all relevant stakeholders, including design teams, manufacturers, contractors, and project owners, to ensure a shared understanding and collaboration in risk management efforts.

7.1 DATA COLLECTION & ANALYSIS

RISK ANALYSIS PROCESS -

7.1.1 Risk Identification

Risk analysis, a component of the risk management process, deals with the causes and effects of events which cause harm. The aim behind such analysis is a precise and objective calculation of risk. To the extent that this is possible, it allows the decision-making process to be more certain. The essence of risk analysis is that it attempts to capture all feasible options and to analyses the various outcomes of any decision.

7.1.2 Risk Analysis

Risk analysis involves assessing the identified risks. This first requires that the risks are quantified in terms of their effect on cost, time or revenue. They can be analysed by measuring their effects on the economic parameters of the project or process. The use of risk analysis gives an insight into what happens if the project does not proceed according to plan.

Collecting responses from Google form survey we get, Risk are categorized in

Very Low	Low	Medium	High	Very High

When conducting risk analysis in precast structures, data analysis techniques can help in quantifying and understanding risks. Here are some commonly used techniques:

1. Failure Mode and Effects Analysis (FMEA): FMEA is a systematic approach for identifying and prioritizing potential failure modes within a system. It involves analyzing each component or process involved in the precast prefabricated structure to determine failure modes, their causes, potential effects, and the likelihood of occurrence. FMEA helps in identifying high-risk areas that require mitigation measures.

2. Fault Tree Analysis (FTA): FTA is a deductive analysis technique used to identify the causes of specific undesired events or system failures. It involves constructing a logical diagram that traces backward from the failure event to its potential causes, using logic gates such as AND, OR, and NOT. FTA helps in understanding the combinations of events that can lead to a particular failure and aids in identifying critical risk factors.
3. Sensitivity Analysis: Sensitivity analysis helps in understanding how changes in input parameters or assumptions affect the outcomes of a risk analysis. By systematically varying the values of different factors and observing their impact on the risk assessment results, sensitivity analysis allows for the identification of critical variables that significantly influence the risk levels. This information helps prioritize risk mitigation efforts.
4. Statistical Analysis: Statistical analysis techniques, such as regression analysis, hypothesis testing, and correlation analysis, can be employed to analyze historical data and identify trends, patterns, and relationships. Statistical analysis can help in assessing the likelihood of specific events or failures, determining the significance of risk factors, and validating risk assessment models.
5. Reliability Analysis: Reliability analysis focuses on evaluating the probability of failure- free performance over a specified period. It involves analyzing the reliability characteristics of components, systems, or processes to estimate failure rates, mean time to failure, and other reliability metrics. Reliability analysis aids in assessing the structural integrity and durability of precast prefabricated structures.

These data analysis techniques can be used individually or in combination, depending on the specific needs and requirements of the risk analysis for precast prefabricated structures. It is important to ensure that the data used in the analysis is accurate, reliable, and representative of the system being assessed.

VIII. RESULTS

The survey concludes that following are the major risk which impact on the construction of precast structure :- Structural Integrity, Transportation Risk ,Handling Risk., Environmental Risk ,Quality control Risk, Project management Risk, Site Safety Risk
,Manufacturing Risk, Time Risk, Design Risk, Financial and Legal risk, Risks associated with human such as Injuries due to various Reasons.

8.1 Identification of the main risks in Precast Bridge construction project.

Identifying and assessing the main risks in Precast Bridge construction project is a critical aspect of risk analysis and management. Some of the common risks associated with Precast Bridge construction project. Include:

1. Site Safety risks: -Precast Prefabricated Bridge construction project. Projects involve significant heights, which pose a risk to workers and the public. Safety risks include falls, slips, trips, and the collapse of structures.
2. Handling Risk and transportation risk: -Handling risk in precast prefabricated structures involves identifying potentialhazards, implementing mitigation measures, and ensuring proper quality control and safety protocols throughout the construction process. Here are some key considerations for managing risk in precast prefabricated structures Quality Control, Transportation and Handling, Site Preparation, Installation and Connection, Collaboration and Communication, Safety Measures.
3. Design error Risk: - Errors or omissions in the design and engineering phase can have significant consequences during manufacturing. Precast elements are manufactured based on detailed designs and engineering calculations. Mistakes in these documents can result in structural deficiencies or other issues.
4. Manufacturing Risk: -Precast prefabricated structures offer several advantages in terms of speed, quality, and cost-effectiveness.
5. Quality Control: Maintaining consistent quality across all precast elements can be challenging.Variations in raw materials, manufacturing processes, and workmanship can lead to inconsistencies in the final product.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

8.2 Report of data received from Google form survey:

Risks	Very Low%	Low %	Medium%	High %	Very High%
structural Integrity	5.30%	31.30%	59.30%	4%	5.30%
Transportation	2.70%	5.30%	81.30%	9.30%	1.30%
Handling	4%	6.70%	6.70%	9.30%	73.30%
Environmental	4%	16%	34.70%	39.30%	4%
Project Management	5.30%	14.30%	34.70%	40.00%	5.30%
Site Safety	6.70%	10.70%	6.70%	66.70%	9.30%
Manufacturing	5.30%	6.70%	18.70%	66.70%	2.70%
Time management	5.30%	13.30%	37.30%	32%	12%
Design errors	4%	13.30%	41%	21.30%	21.30%
Financial & Legal	6.70%	17.30%	32%	33.30%	10.70%
Quality control	6.70%	10.70%	40%	29.30%	13.30%

Table 1: Report of data received from google form survey for Risks

Injuries Due To	Catastrophe	Major	Moderate	Significant	Negligible
Structural Collapse	57.30%	24%	13.30%	5.30%	0%
Lifting	1.30%	53%	41.30%	4%	0%
Congested Area	5.30%	37.30%	34.70%	20%	2.70%
Working at Height	10.70%	53.30%	26.70%	5.30%	4%
Heavy Equipment	6.70%	30.70%	34.70%	22.70%	5.30%
Small Tools & Equipment	6.70%	20%	42.70%	17.30%	13.30%

Table 2: Report of data received from google form survey for Injuries.

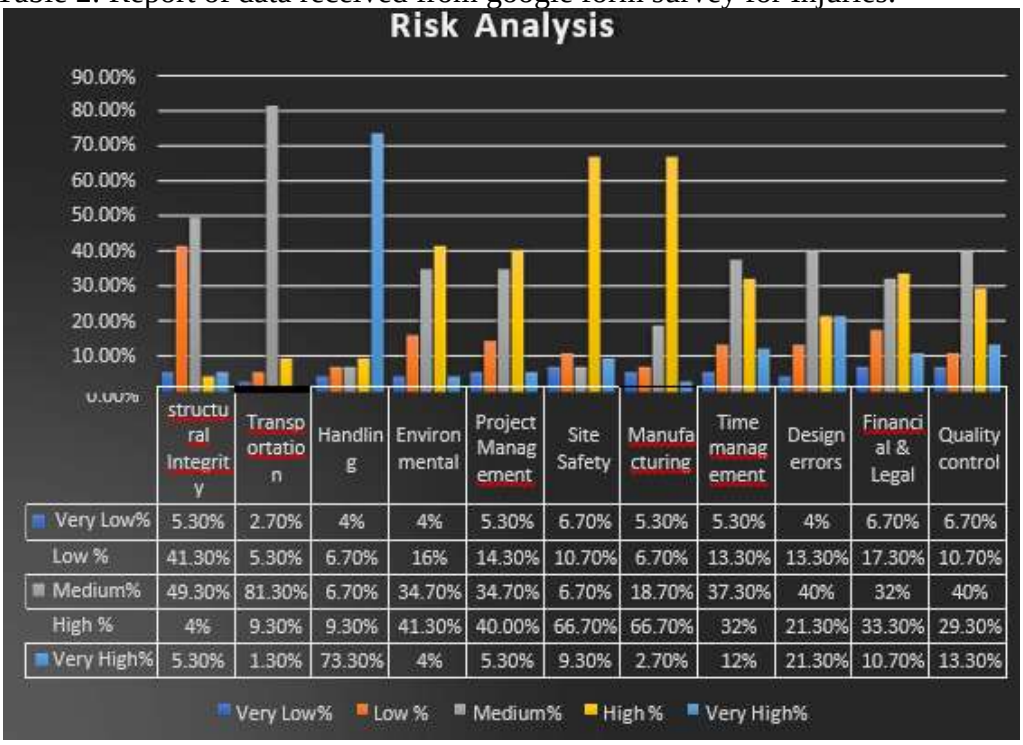

Fig. 3: Risk Analysis in Precast Structure construction.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

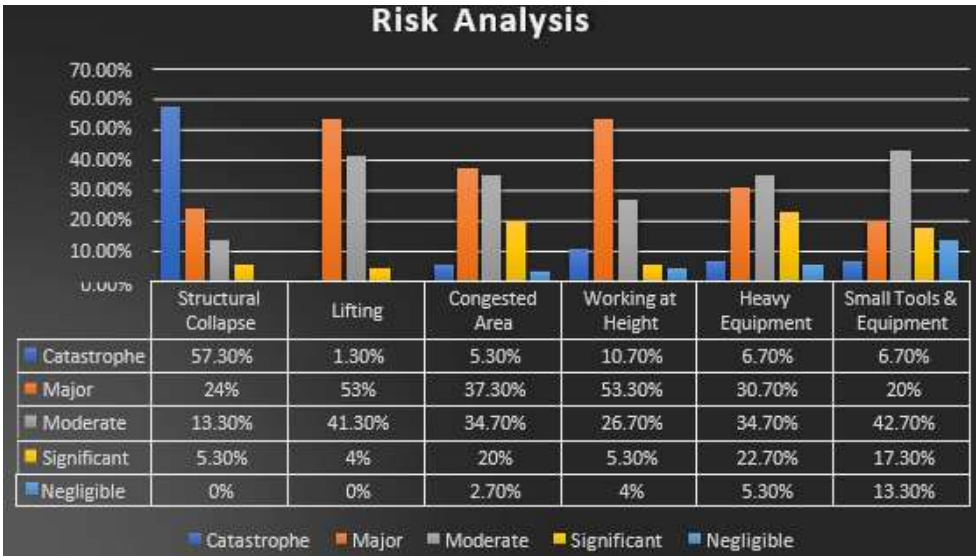

Fig. 4: Risk Analysis of Injuries

8.3 Identified main risk by questionnaire survey on pie chart:- For each Risk there are pie charts showing their percentages:

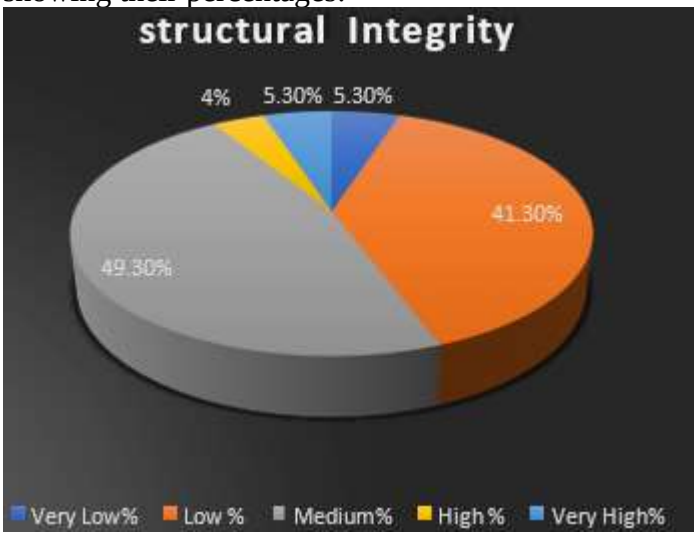

Fig 5: - Impact of Structural Integrity

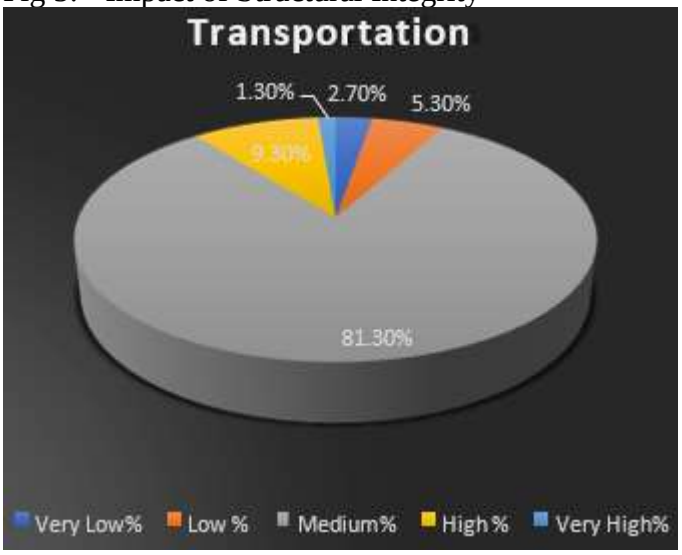

Fig 6: - Impact of transportation risk

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

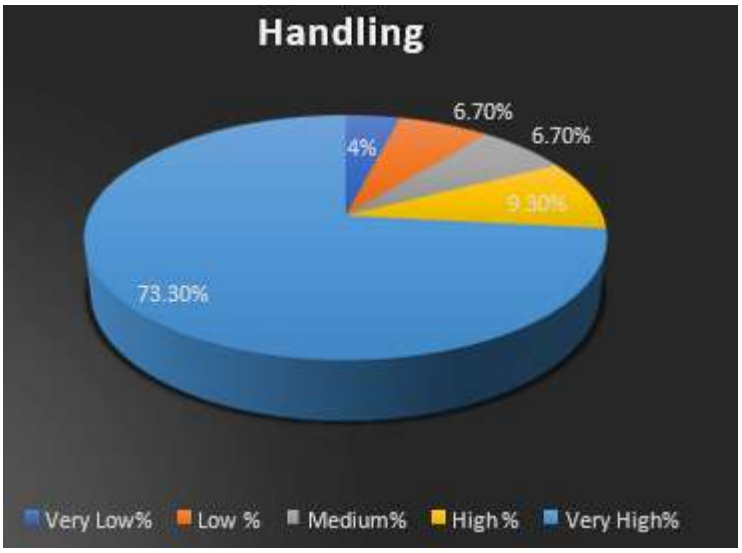

Fig 7: - Impact of handling Risk

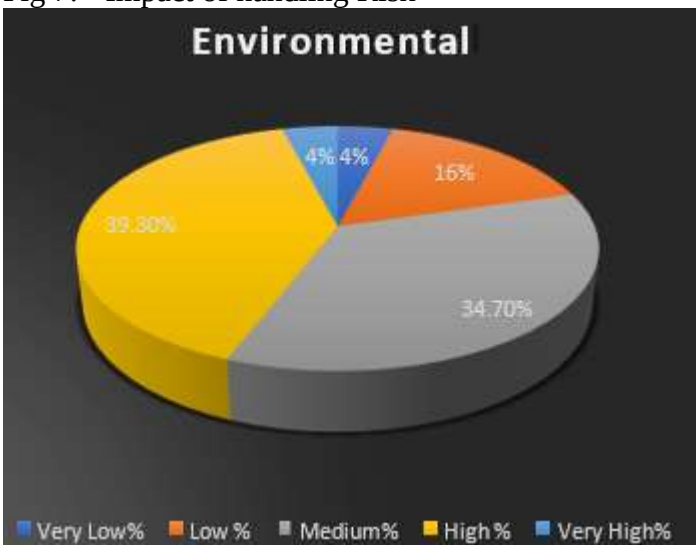

Fig 8: - Impact of environmental risk

Fig 9: - Impact of Project Management risk

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

Fig 10: - Impact of site safety Risk

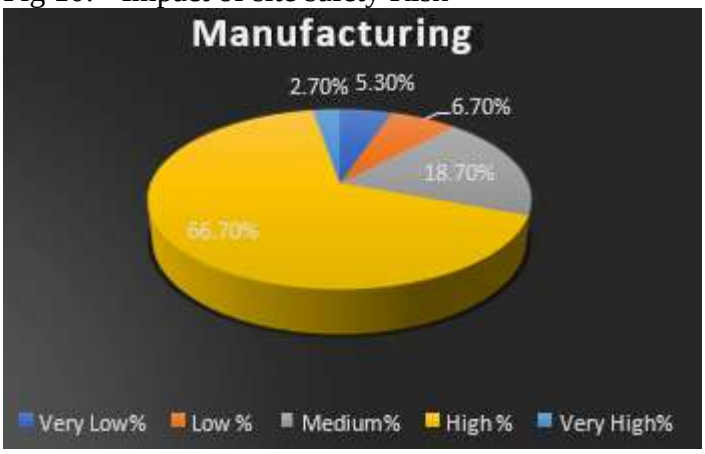

Fig 11: - Impact of Manufacturing Risk

Fig 12: - Impact of Time Management Risk

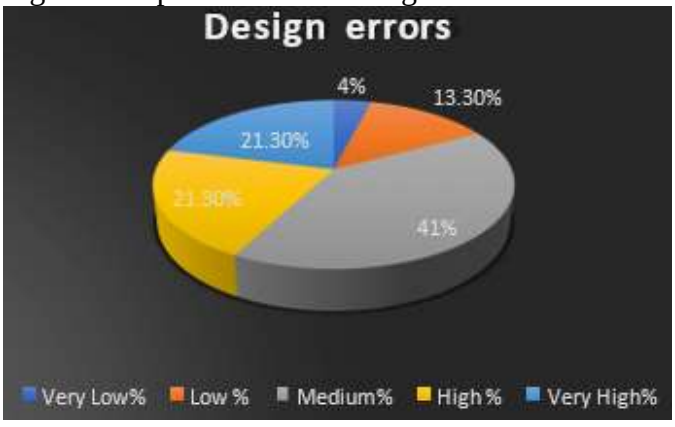

Fig 13: - Impact of design errors

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

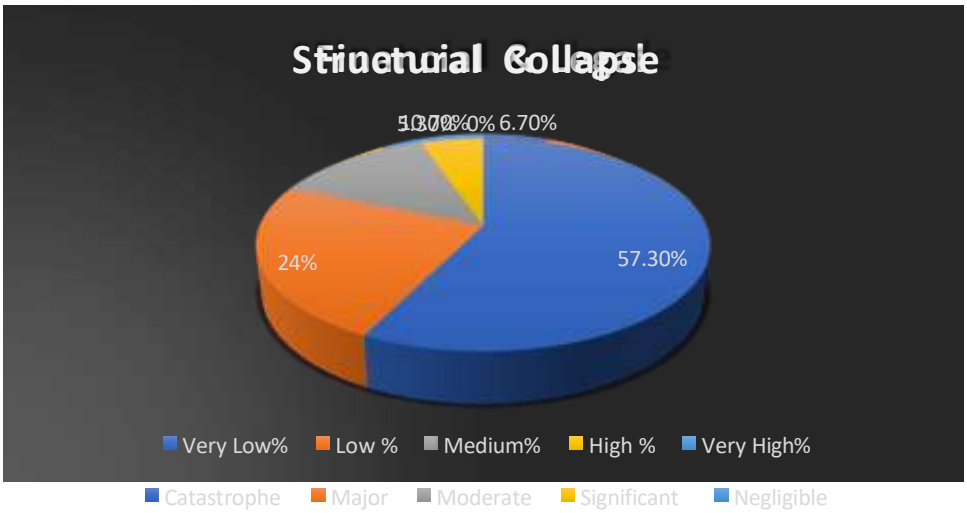

Fig 14: - Impact of Financial And Legal Risk

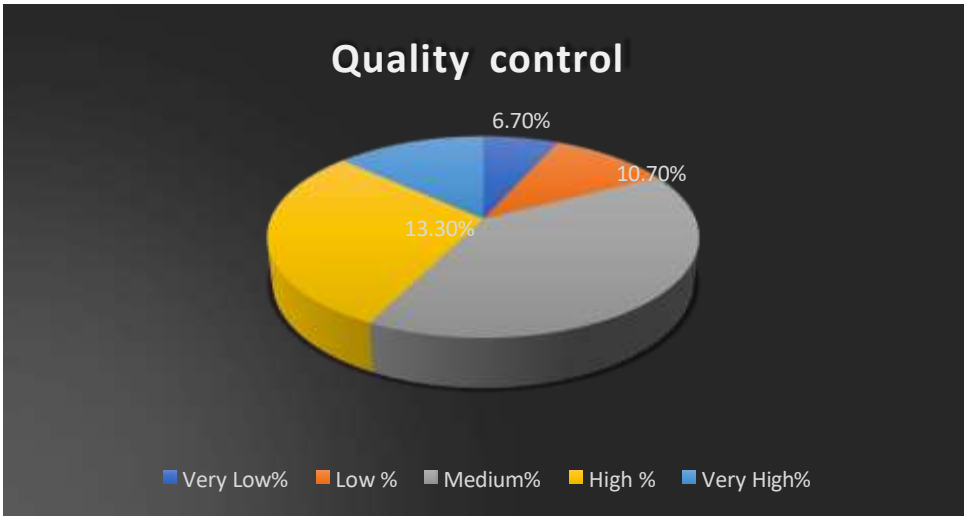

Fig 15: - Impact of quality control risk

8.4 Pie charts showing Risk Analysis of Injuries in precast structure of bridge.

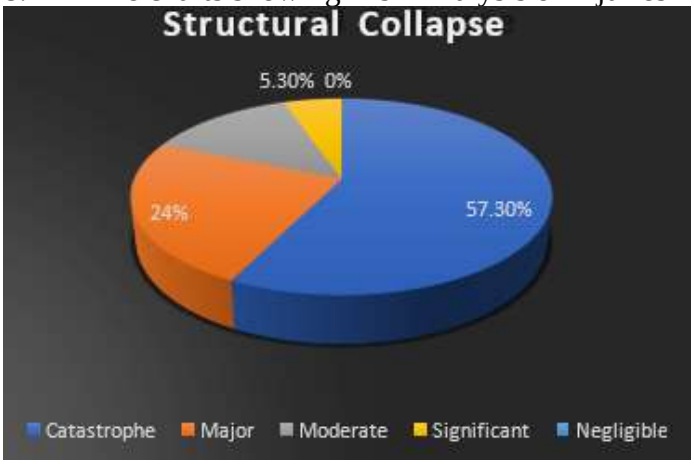

Fig 16: - Injuries Due to structural collapse

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

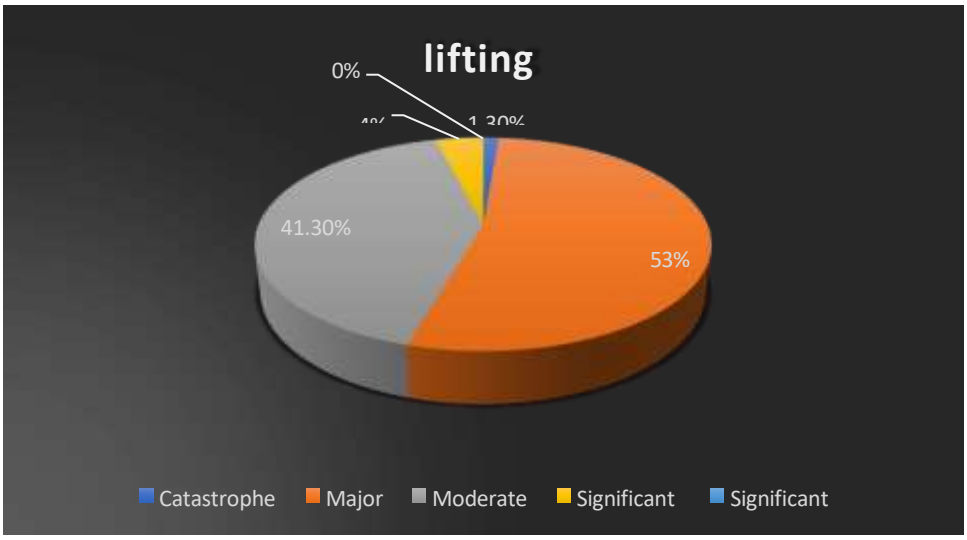

Fig 17: - Injuries due to lifting

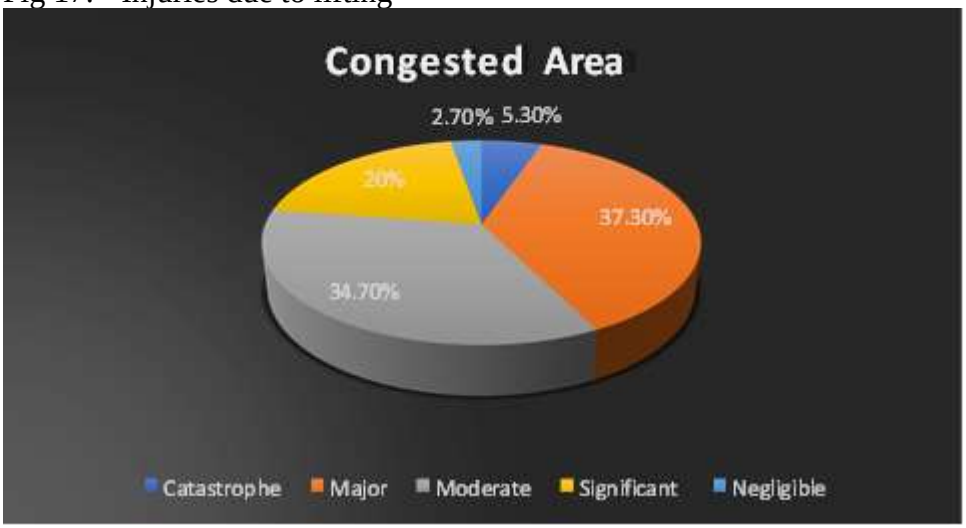

Fig 18: - Injuries Due to Congested Area

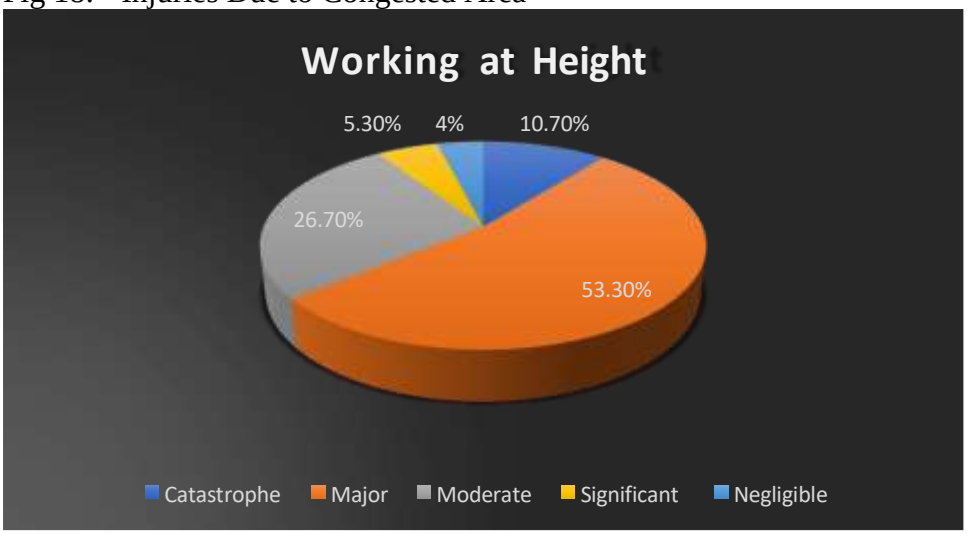

Fig 19: - Injuries Due to Working at height.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 7, No.1, July : 2024

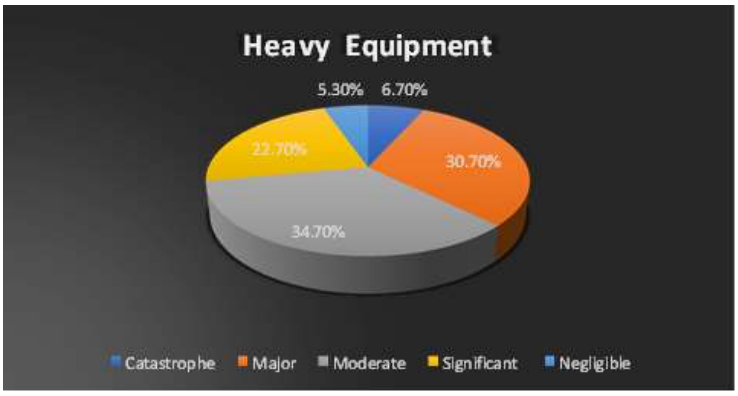

Fig 20: - Injuries due to heavy equipment

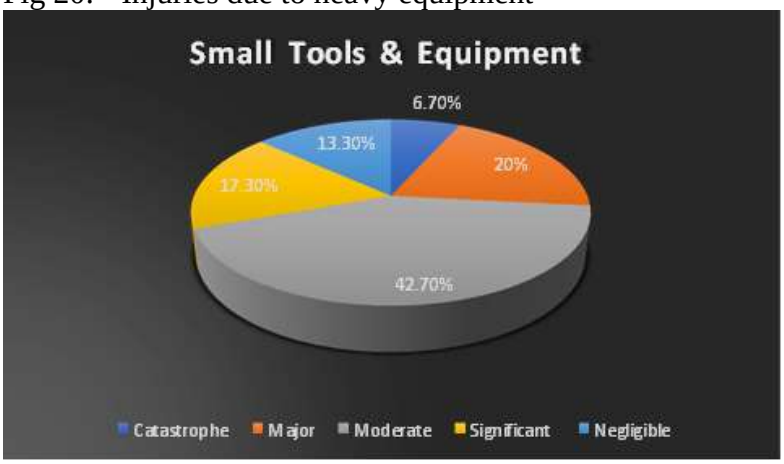

Fig 21: - Injuries Due to Small tools and Equipment

IX. DISCUSSION

9.1 Interpretation of the results in relation to the research questions and objectives:

The interpretation of the results in relation to the research questions and objectives is an essential aspect of any research study. In the case of the risk analysis in Precast Prefabricated Bridge construction project. The results obtained from the data analysis will be interpreted in the context of the research questions and objectives. The research questions and objectives will guide the interpretation of the results and help to answer the research questions. For example, if the research question is "What are the main risks associated with Precast Prefabricated Bridge construction project." the results will beinterpreted to identify and assess the main risks, such as Site Safety Risk, Handling Risk, Manufacturing Risk, Design error risk, Quality control risk.

Recommendations for future research

Future research on risk analysis in precast prefabricated structures can focus on several areasto enhance understanding and improve risk assessment methodologies. Here are some recommendations:

9.1.1 Long-Term Performance: Investigate the long-term performance of precast prefabricated structures by analyze the effects of aging, durability, and degradation mechanisms. This research can help identify potential risks associated with long-term exposure to environmental factors, such as corrosion, material deterioration, and structural integrity over time.

9.1.2 Advanced Modeling and Simulation: Develop advanced modeling and simulation techniques that accurately capture the behavior of precast prefabricated structures under different loadings andenvironmental conditions. This can include the development of sophisticated finite element models,multi-physics simulations, and computational tools that consider the complexities of connections, interfaces, and interactions between components.

9.1.3 Reliability and Statistical Analysis: Explore advanced reliability analysis techniques toquantifythe reliability and safety levels of precast prefabricated structures. This can involve

incorporating time-dependent factors, probabilistic modeling, and reliability-based design approaches to assess theoverall system reliability and failure probabilities more accurately.

9.1.4 Data-Driven Approaches: Utilize big data and machine learning techniques to analyze large datasets from previous precast prefabricated projects. This research can help identifypatterns, correlations, and predictive indicators of risks and failures. By leveraging data- driven approaches, itmay be possible to develop early warning systems and predictive models for risk mitigation and decision-making.

9.1.5 Sustainability and Resilience: Investigate the risks associated with sustainability and resilienceof precast prefabricated structures. This can include assessing the environmental impacts, life cycleassessment, energy efficiency, and the ability of the structures to withstandextreme events, such asearthquakes, hurricanes, or fire.

9.1.6 Standardization and Best Practices: Develop standardized guidelines and best practices for riskanalysis in precast prefabricated structures. This can help ensure consistency and reliability across the industry, facilitating better risk assessment, communication, and mitigation strategies.

X CONCLUSIONS

In this study, a comprehensive investigation of the main risks in Precast bridge construction sector is shown. From the questionnaire survey regulated with 75 civil engineers in Nashik who work under bridge sector, risk factors affecting the construction sector are identified by deep observation on site. The critical risks challenging the performance of bridge construction projects have been identified in this study.

The demographical analysis of the respondents, based on the age the respondents were between 25 to 45 years of age. Based on the designation the highest respondents were Site Engineers had a percentage of 56%. Based on the experience the highest respondents were 1 to 5 years of experience had 80%.

The six main risks identified were analysed, the first three highest scores were considered as the most critical factors in the bridge projects in this study. The main six risk identified were as follows: Structural integrity (59.30%), Transportation Risk (81.30%), Handling Risk (73.30%), Site safety risk (66.70%), Manufacturing Risk (66.70%), & Design errors Risk (41%).

The data received from the survey done by using google form was extracted in the Micro soft Excel Software. Using this software the data was analyzed in percentage format and converted into pie charts and bar graphs to showcase the results.

From the data received from the survey we also got to know the impact of injuries due to various factors in precast bridge construction, the factors are as follows : Injuries due to structural collapse(catastrophe- 57.30%),lifting (Major-53%), working at congested areas(Major-37.30%), working at height(Major-53.30%), heavy equipment(moderate-34.70%), small tools and equipment(moderate – 42.70%). Charts are drawn to know the impact of injury on various factors in precast construction and they are analysed and the results are provided.

To avoid these risks, it is essential to follow a comprehensive and systematic design process that considers all relevant factors. Some actions that can help avoid these risks include engaging experts in bridge construction to provide insights and recommendations on the design and construction process. Follow established design standards and guidelines to ensure that all critical design elements are considered and that the bridge is designed to meet the required safety and quality. These also includes conducting thorough site investigations to understand the conditions, geological hazards and environmental factors. The other most important but not taking in process is of implementing quality control measures throughout the process to ensure that the bridge is built to the required specifications and standards. By following these actions it is possible to avoid the risks in bridge construction to an extent and ensure the bridge is safe, stable and meets the intended use and lifespan.

Limitations of the study and suggestions for future research

The study of risk analysis in precast prefabricated structures, like any research endeavor, is subject to certain limitations. Here are some common limitations that researchers may encounter:

1. Data Availability and Quality: The availability of comprehensive and high-quality data specific to precast prefabricated structures may be limited. Data on past failures, incidents, and performance of such structures may not be readily accessible or may lack necessary detail. This limitation can affect the accuracy and reliability of risk analysis results.
2. Limited Research Scope: Conducting risk analysis for precast prefabricated structures often involves narrowing the scope to specific types of structures, components, or hazards. This can limit the generalizability of the findings and may not capture the full range of risks associated with all precast prefabricated structures.
3. Lack of Standardization: The field of risk analysis for precast prefabricated structures may lack standardized methodologies, terminology, and assessment criteria. This can result in variations in approaches and hinder direct comparisons between different studies. The absence of uniform standards can also make it challenging to establish consistent risk mitigation strategies.
4. Complex Interactions: Precast prefabricated structures involve various components, connections, and interfaces. The interactions between these elements can be intricate, and capturing all the dependencies and failure modes in a risk analysis can be challenging. The complexity of the systems may necessitate simplifications or assumptions that may introduce uncertainties into the analysis.
5. Limited Long-Term Data: Assessing long-term risks in precast prefabricated structures requires data on the performance and behavior of these structures over extended periods. However, long-term data may be scarce, especially for newer construction techniques or innovative designs. This limitation can affect the accuracy of predictions regarding long-term risks and performance.
6. Dynamic Nature of Risks: Risks associated with precast prefabricated structures can evolve over time due to changes in design, construction practices, materials, and environmental factors. Conducting a risk analysis at a particular point may not capture the evolving nature ofrisks or consider future developments that could impact risk profiles.
7. External Factors: Risk analysis in precast prefabricated structures often relies on assumptions about external factors, such as climate conditions, usage patterns, and maintenance practices. Changes in these factors over time or variations in different geographical locations may introduce uncertainties or inaccuracies in the risk analysis results. Suggestions for future research may include:
1. Comparative Analysis: Conduct a comparative analysis of different risk analysis methodologies and tools used in the assessment of precast prefabricated structures. Evaluate their strengths, limitations, and applicability to different types of projects. This research can help identify the most effective and efficient approaches for risk analysis in this specific context.
2. Multi-Hazard Assessment: Investigate the risks associated with multiple hazards and their interactions in precast prefabricated structures. Assess how various hazards, such as earthquakes, hurricanes, fire, and environmental factors, can affect the performance and safety of these structures.Develop comprehensive risk assessment frameworks that consider the combined effects of multiple hazards.
3. Life Cycle Analysis: Explore the integration of life cycle analysis (LCA) into risk analysis for precast prefabricated structures. Evaluate the environmental impacts associated with different stages of the structure's life cycle, from raw material extraction to end-of-life disposal. Incorporate LCA metrics and indicators into risk assessment models to assess the sustainability and resilience of precast prefabricated structures.
4. Human Factors and Occupant Safety: Investigate the role of human factors and occupant behaviorin risk analysis for precast prefabricated structures. Assess how human actions and decision-making during the design, construction, and operation stages can influence risks and safety. Analyze occupant safety considerations, such as evacuation procedures, fire safety, and accessibility, within the risk analysis framework.
5. Integration of Digital Technologies: Explore the integration of digital technologies, such asBuilding Information Modeling (BIM), Internet of Things (IoT), and artificial intelligence (AI), into

risk analysis for precast prefabricated structures. Investigate how these technologies can improve data collection, risk assessment, and real-time monitoring of structures to enhance risk analysis accuracy and enable proactive risk management.

6. Optimization of Risk Mitigation Strategies: Focus on optimizing risk mitigation strategies for precast prefabricated structures. Use optimization techniques to identify the most cost- effective and efficient risk mitigation measures, considering factors such as construction processes, material selection, maintenance protocols, and quality control procedures. This research can help minimize risks while optimizing resources and project outcomes.
7. Stakeholder Engagement and Decision-Making: Investigate the role of stakeholder engagement and decision-making in risk analysis for precast prefabricated structures. Examine how different stakeholders perceive and prioritize risks, and how their perspectives can influence risk assessment and mitigation strategies. Develop frameworks and tools to facilitate effective stakeholder communication, collaboration, and decision-making in risk analysis processes.

REFERENCES

1. P. Karthigai Priya, “Risk analysis in Precast Industry”, International Journal for Research in Engineering Application & Management (IJREAM), Vol-05, Issue-02, May 2019.
2. Goran Cirovic,“Risk analysis in Precast Industry”, International Journal for Research in Engineering Application & Management (IJREAM), Vol-05, Issue-02, May 2019.
3. Dziadoaz and Rejment, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
4. Neeraj and Balasubramaniyan, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
5. Parvathy et al, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
6. Kinnaresh Patel, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
7. Rafiq M. Choudhry, etal., “Bridge Project development risk management”, EPRA International Journal of Multidisciplinary Research (IJMR), Volume: 6, Issue:1, January 2020.
8. Chau Ngoc Dang, et al., “Bridge Project development risk management”, EPRA International Journal of Multidisciplinary Research (IJMR), Volume: 6, Issue:1, January 2020.
9. Kansal and Manoj, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
10. Naser and Kodur, “Risk analysis in Bridge construction Project”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017
11. V. Devi, “A study on risk analysis in construction project,” International Research Journal of Engineering and Technology, 5(5), pp.4317-4321, 2018.
12. V. Dixit, “Risk assessment of different sourcing contract scenarios in project procurement,” International Journal of Construction Management, 22(8), 1537-1549, 2022.
13. N. Alsaadi, and N. Norhayizakuan, “The Impact of Risk Management Practices on the Performance of Construction Projects,” Studies of Applied Economics, 39(4), 1-10, 2021.
14. [2] A. Boateng, C. Ameyaw and S. Mensah, “Assessment of systematic risk management practices on building construction projects in Ghana,” International Journal of Construction Management, 1-10, 2020.
15. [3] G. Chandubai, J. Pitroda and A. Makwana, “Risk Management in High Rise Construction Projects in Surat City,” International Journal of Technical Innovation in Modern Engineering & Science, 160-167, 2019.
16. [4] A. De Marco and M. Thaheem, “Risk analysis in construction projects: a practical selection methodology,” American Journal of Applied Sciences, 11(1), pp.74-84, 2014