

A Case Study on Safety Hazard, Risk Identification and Management to Improve Engineering Procurement, Construction (EPC) Contracts - A REVIEW

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Abstract - The work is mainly focused on the risk identification and management in EPC contracts in construction. This paper includes systematic literature reviews on to find the gap between the existing method and other method for project management & its risk of failure. Investigating the significance of creating a true risk management culture within the organization. Data collection and analysis of questionnaire for risk identification within construction industry. Realize usually Cost, safety, quality, environmental performance, community relations and minimizing operational expenditure. Provide a Risk Management Model to assist EPC contractors to manage project risks in a Structured and Integrated manner. Develop the decision support tool and its processes, features and management strategy and improve future research opportunities

Key Words: Engineering, Procurement, and Construction (EPC) contracts, Risk Management model.

1. INTRODUCTION:

Engineering, Procurement, and Construction (EPC) contracts have been widely used in the construction and infrastructure industries. EPC contracts provide appropriate framework for the execution of complex projects, ensuring seamless coordination among various stakeholders.

An EPC contract is a contractual agreement between an owner or developer of a project and an EPC contractor. It combines the design, procurement, and construction phases into a single, integrated contract. In an EPC contract, the contractor is responsible for the engineering design, procurement of materials and equipment, and the construction or installation of the project.

1.1 Key Features of EPC Contracts:

- 1) Turnkey Approach: EPC contracts are often referred to as "turnkey" contracts, as they involve a holistic approach where the contractor takes full responsibility for the entire project. This includes designing, procuring, and constructing the project to deliver a fully operational facility to the owner.
- 2) Single Point of Contact: EPC contracts provide the owner with a single point of contact for the

entire project, simplifying project management and reducing potential conflicts between multiple contractors.

- 3) Lump-Sum Price: EPC contracts typically have a fixed or lump-sum price, ensuring cost certainty for the owner. This helps manage budgetary constraints and minimizes the risk of cost overruns.
- 4) Time-bound Completion: EPC contracts include specific timelines for project completion, holding the contractor accountable for meeting deadlines. This ensures timely delivery of the project, minimizing delays and associated costs.
- 5) Risk Allocation: EPC contracts generally allocate risks and liabilities to the contractor. The contractor assumes responsibility for any design flaws, construction defects, or delays, providing the owner with a greater degree of protection.

1.2 Significance of EPC Contracts:

EPC contracts offer several advantages for both project owners and contractors:

- 1) Streamlined Project Execution: By combining engineering, procurement, and construction functions, EPC contracts promote efficient project execution, reducing coordination challenges and enhancing overall project control.
- 2) Reduced Administrative Burden: Owners can focus on project oversight and decision-making, as the EPC contractor assumes responsibility for managing the various project aspects, such as subcontracting, scheduling, and quality control.
- 3) Increased Cost Certainty: The lump-sum nature of EPC contracts ensures that project costs are established upfront, mitigating the risk of unexpected budget overruns.
- 4) Enhanced Risk Management: EPC contracts allow for the effective transfer of risks from the owner to the contractor. This encourages the contractor to diligently manage risks and deliver the project within the agreed-upon parameters.

- 5) **Improved Quality and Performance:** EPC contractors are accountable for the overall project, incentivizing them to deliver a high-quality facility that meets or exceeds the owner's expectations.

The risks in a construction project are different with different types of contracts. This is due to the different types of projects life cycle in each contract type. One of the ways to achieve sustainable development in Safety management plays a crucial role in the construction industry, ensuring the well-being of workers and the prevention of accidents and injuries on construction sites. This introduction provides an overview of safety management in construction, emphasizing its significance, key principles, and the proactive approach required to maintain a safe working environment.

1.3 Importance of Safety Management in Construction:

The construction industry is inherently hazardous due to the presence of heavy machinery, complex tasks, and dynamic work environments. Safety management aims to identify and control potential risks to safeguard the health and safety of workers, visitors, and the general public. By prioritizing safety, construction companies can minimize workplace incidents, improve productivity, reduce costs associated with accidents, and maintain a positive reputation.

1.4 Key Principles of Safety Management:

- 1) **Risk Assessment:** Safety management begins with a thorough assessment of potential hazards and risks associated with construction activities. This involves identifying potential sources of danger, evaluating their severity and likelihood, and implementing appropriate control measures to mitigate or eliminate risks.
- 2) **Safety Policies and Procedures:** Establishing clear and comprehensive safety policies and procedures is essential for effective safety management. These guidelines should cover various aspects, such as personal protective equipment (PPE), safe work practices, emergency procedures, and communication protocols, ensuring that all workers are aware of and adhere to safety protocols.
- 3) **Training and Education:** Proper training and education are fundamental to safety management in construction. Workers should receive comprehensive safety training, including hazard

identification, safe work procedures, equipment operation, and emergency response. Ongoing education and awareness programs further enhance safety culture and promote continuous improvement.

- 4) **Safety Inspections and Audits:** Regular inspections and audits are conducted to identify potential safety deficiencies and ensure compliance with established safety standards. Inspections may include assessments of equipment, machinery, scaffolding, electrical systems, and overall site conditions. Findings from inspections and audits help identify corrective actions and preventive measures.
- 5) **Incident Investigation and Lessons Learned:** Safety management involves a proactive approach to incident investigation. When accidents or near misses occur, thorough investigations are conducted to determine the root causes and develop preventive measures. Lessons learned from incidents are shared across the organization to raise awareness and prevent similar incidents in the future. A country is by creating a strong construction industry towards global competition.

Risk management plays a vital role in the construction industry, as it allows for the identification, assessment, and mitigation of potential risks that can impact project success. This introduction provides an overview of risk management in construction, emphasizing its significance, key principles, and the proactive approach required to effectively manage risks throughout the project lifecycle.

1.5 Importance of Risk Management in Construction:

Construction projects are inherently complex and involve various uncertainties and potential risks. Effective risk management is essential to minimize project disruptions, avoid costly delays and budget overruns, enhance safety, and protect the interests of all stakeholders involved. By systematically addressing and managing risks, construction companies can increase the likelihood of project success and achieve desired outcomes.

1.6 Key Principles of Risk Management:

1. **Risk Identification:** The first step in risk management is to identify potential risks that may affect the project. This involves systematically analyzing all aspects of the

project, including design, construction methods, procurement, scheduling, financial factors, environmental considerations, and regulatory compliance. Various techniques, such as brainstorming, checklists, and historical data analysis, can aid in identifying potential risks.

- 2. Risk Assessment and Analysis:** Once risks are identified, a thorough assessment and analysis are conducted to evaluate their potential impact and likelihood. Risks are typically categorized based on their severity and probability, enabling prioritization and allocation of resources for mitigation. Qualitative and quantitative risk assessment methods, such as risk matrices and Monte Carlo simulations, can be employed to support informed decision-making.
- 3. Risk Mitigation:** Risk mitigation involves developing strategies and actions to reduce the likelihood and impact of identified risks. This may include implementing safety measures, revising design specifications, adopting alternative construction methods, enhancing project planning, and establishing contingency plans. The goal is to proactively address risks and minimize their potential consequences.
- 4. Risk Monitoring and Control:** Throughout the project lifecycle, risks should be continuously monitored and controlled to ensure that mitigation measures remain effective. Regular reviews and updates of risk registers, progress reports, and communication among project stakeholders are crucial. Early detection of emerging risks allows for prompt adjustments to project plans and strategies.
- 5. Lessons Learned and Continuous Improvement:** Risk management in construction involves learning from past experiences and incorporating lessons learned into future projects. Through post-project evaluations and analysis, valuable insights are gained, and best practices are identified. Continuous improvement in risk management processes and procedures is key to enhancing overall project performance and reducing future risks.

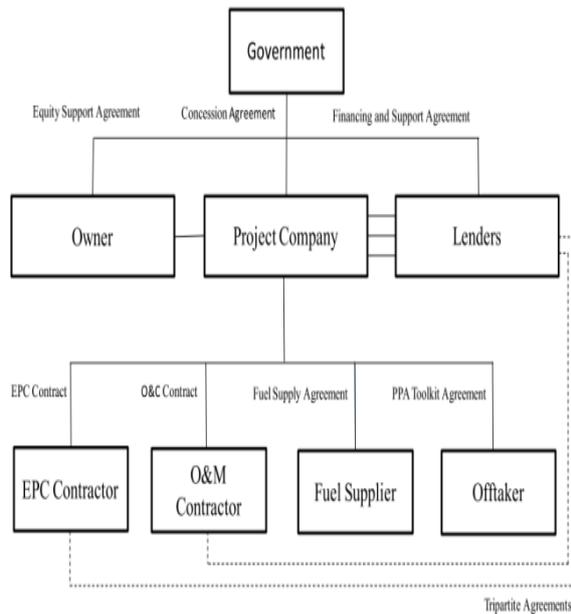
1.7 Proactive Approach to Risk Management:

A proactive approach to risk management in construction is vital for successful outcomes. This approach involves:

- 1. Early Risk Identification:** Identifying risks as early as possible in the project lifecycle allows for better planning and allocation of resources to mitigate potential issues. Early involvement of stakeholders, including designers, contractors, and suppliers, facilitates comprehensive risk assessment.
- 2. Collaboration and Communication:** Effective risk management requires open and transparent communication among all project participants. Collaborative efforts enable the sharing of information, perspectives, and expertise, leading to more accurate risk assessments and the development of appropriate mitigation strategies.
- 3. Risk Allocation and Contractual Provisions:** Clear risk allocation among project stakeholders should be established in contracts to ensure everyone understands their responsibilities. Well-defined contractual provisions, such as insurance requirements and dispute resolution mechanisms, contribute to effective risk management and minimize potential conflicts.
- 4. Continuous Risk Monitoring:** Risk management is an ongoing process, and risks should be continually monitored and reassessed throughout the project. Regular project reviews, site inspections, and performance evaluations help identify emerging risks and ensure that mitigation measures remain effective.

1.8 State of The Art of Engineering, Procurement, and Construction:

Some researchers have provided definitions of EPC, and it can be concluded that EPC is a project management concept that designs, procures materials and equipment, and constructs. The basic contractual structure of an EPC contract is illustrated in Figure taking an example of a project financed power project, while in reality, detailed structures can differ from one project



(Fig 1.1: Basic structure in an EPC Contract)

The EPC Performance Related Indicators were poor design, poor project planning, bad estimation, incomplete design, stakeholder involvement that does not accommodate disputes, loss of reputation, old delivery of goods, poor site supervision, poor project control, changes in project implementation, delay in delivery of building materials on site, inappropriate quality of building materials, redo of inadequate tasks, inadequate or inefficient equipment or machinery sub-contractors, unskilled labor, labor changes, accidents or incidents, excessive bureaucratic inclusion. In analyzing the productivity of this EPC contract, it is necessary to know in advance what risks might occur in the application of the contract

1.9 State of The Art of Risk in Engineering Procurement Construction:

EPC project risks have been associated with construction, design, payment, client, and sub-contractor (procurement) risks. EPC contracts tend to handle problems with greater sophistication than other types of construction contracts. The prerequisites needed for the successful functioning of the EPC approach include that the contractor understands, manages and influences the allocation of risk and ready to assume the level of risks. One risk from the owner's perception is the contractor's claim. Causes of contractor claims in EPC projects are external risks, client's organizational behavior, and project definitions in contracts. Causes of contractor claims are analyzed among others as external risks (sociopolitical risk, economic risk and natural hazards), client organization behavior (premature

payments, order changes, and inefficient processing), and project definitions in contracts (unclear scope of work and technical specifications). There are several potential risks in EPC projects such as potential delays in schedules, quality problems, hostile relations, and information interruptions. This is because an EPC project typically has a long, large-scale, and multi-participatory process

2 BODY OF PAPER:

The study aims to propose methodology for a case study on Safety Hazard, Risk Identification and Management in EPC Contracts for time and cost saving. The methodology will be implemented by using field data associated with case study.

3 LITERATURE REVIEW:

1.Lingard and Rowlinson (2005) explores the topic of occupational health and safety in construction project management. The authors delve into various aspects of safety management, including risk assessment, hazard identification, safety planning, and the role of project managers in ensuring a safe working environment. The paper provides a comprehensive overview of safety management practices and highlights the importance of integrating safety considerations into the project management process. It offers insights into the challenges faced in managing safety in construction projects and provides recommendations for improving safety performance.

2.Loosemore and Al-Tabtabai's (2011) paper provides valuable insights into the relationship between contractors' perception of risk importance and their corresponding mitigation measures in the construction industry. By emphasizing the need for targeted risk management approaches, the study contributes to advancing effective risk mitigation practices in construction projects. . By highlighting the importance of aligning risk perception with appropriate mitigation strategies, it emphasizes the need for contractors to prioritize their risk management efforts effectively. The study contributes to the existing literature and underscores the significance of a tailored approach to risk mitigation based on risk perception.

3.Chien and Shih (2015) reviewed the literature on risk management in EPC projects and presented a case study of a power plant project in Taiwan. The study found that risk identification and assessment are critical factors in successful risk management. The authors emphasized the importance of risk response strategies, such as risk avoidance, reduction, transfer, and acceptance, and highlighted the need for effective risk communication

and risk-sharing mechanisms between project stakeholders. The study also showed that the use of risk management tools and techniques, such as Monte Carlo simulation and fuzzy logic, can help project managers better understand and manage project risks.

4.Elhag and Boussabaine (2010) emphasized the importance of risk management in EPC projects and identified several risk factors, such as design changes, unexpected weather conditions, and delays in procurement and delivery. The authors highlighted the need for a systematic risk management approach, including risk identification, assessment, and response. The study showed that effective risk management can help reduce project risk and increase project success. The authors also emphasized the importance of effective risk communication and risk-sharing mechanisms between project stakeholders.

5.Olawale and Sun (2010) identified risk factors in EPC projects, such as changes in scope, lack of project management expertise, and inadequate communication among stakeholders. The study emphasized the need for a systematic risk management approach, including risk identification, assessment, and response. The authors also highlighted the importance of effective project management practices, such as the use of project management software and tools, to help mitigate project risks. The study showed that effective risk management can help reduce project costs, improve

6.P Walker and Di Sarno (2014) present a conceptual framework for construction project risk management. The paper emphasizes the proactive and systematic nature of risk management, highlighting the need for a structured approach to identify, assess, and respond to risks. The authors propose a four-stage risk management process: risk identification, risk analysis, risk response, and risk monitoring and control. The framework integrates key elements such as risk registers, risk assessment techniques, and risk mitigation strategies to facilitate effective risk management in construction projects. roject quality, and increase project success.

7.Zhang et al. (2018) conducted a literature review on the role of project managers in risk management in EPC projects. The study identified the importance of project managers' leadership skills, communication skills, and risk management experience. The authors emphasized the need for effective risk management processes, such as risk identification, analysis, evaluation, and response.

The study also highlighted the importance of collaboration and communication among project stakeholders, and the need for effective risk-sharing mechanisms. The authors showed that effective risk management can help reduce project risk, increase project success, and ensure the timely and cost-effective delivery of projects.

8.Pan, H., & Zhang, X. (2015) conducted a literature review on safety management in EPC contracts. The study identified that safety management is a critical issue in EPC contracts, especially in the construction phase. The authors emphasized the importance of a comprehensive safety management system, including risk identification, assessment, control, and communication, to ensure the safety of workers and the public. The study also highlighted the importance of safety culture, leadership, and communication among project stakeholders.

9.El-Sayegh and El-Mashaleh (2015) present a case study conducted in the Gulf Region, focusing on risk assessment and management in construction projects. The paper examines the challenges faced by project stakeholders in identifying, assessing, and managing risks in the region's construction industry. The study highlights the specific risks prevalent in the Gulf Region, such as political instability, economic fluctuations, and cultural differences, and explores the strategies employed to address these risks. The findings contribute to the understanding of risk management practices in a specific regional context, offering insights into the unique challenges faced by construction projects in the Gulf Region and the corresponding risk management approaches.

10.Kumaraswamy et al. (2014) conducted a case study of safety management in a large EPC project in Singapore. The study identified several safety challenges, such as complex project scope, tight schedule, and high-risk activities. The authors emphasized the importance of a safety management plan, safety audits, safety training, and safety incentives to ensure safety in the project. The study also highlighted the importance of safety culture and leadership in ensuring safety in the project.

11.Zhou and Li (2013) conducted a study on safety management in EPC projects in China. The study identified several safety issues, such as inadequate safety regulations, lack of safety culture, and poor safety performance. The authors emphasized the importance of

a comprehensive safety management system, including risk identification, assessment, control, and communication, to ensure safety in EPC projects. The study also highlighted the importance of safety leadership and communication among project stakeholders.

12. Flanagan and Norman's book (2013) on "Risk Management and Construction" provides a comprehensive overview of risk management in the construction industry. The authors cover a wide range of topics, including risk identification, assessment, mitigation, and monitoring. The book offers practical guidance on implementing risk management strategies and provides case studies that illustrate real-world applications. The third edition incorporates the latest industry practices and standards, making it a valuable resource for researchers, practitioners, and students interested in understanding and implementing effective risk management in construction projects.

13. Manu et al., (2014) propose a conceptual safety management framework for construction projects. The paper presents a comprehensive model that integrates various elements of safety management, including policy and commitment, planning, implementation, monitoring, and review. The framework emphasizes the importance of a proactive and systematic approach to safety management, highlighting the role of leadership, communication, and training in fostering a safety culture. The study provides valuable insights into the key components and processes of safety management and offers a structured framework for improving safety performance in construction projects.

14. Yang et al. (2018) conducted a study on safety management in EPC projects in China. The study identified several safety issues, such as inadequate safety regulations, lack of safety culture, and poor safety performance. The authors emphasized the importance of safety leadership, safety culture, safety management systems, and safety training in ensuring safety in EPC projects. The study also highlighted the need for effective communication and coordination among project stakeholders to ensure safety in the project.

15. Jaiswal et al. (2016) conducted a study on risk management in EPC contracts in the Indian construction industry. The study identified several risk factors, such as inadequate planning, poor project management, and lack of safety measures. The authors emphasized the importance of risk identification, assessment, and

mitigation in EPC projects. The study also highlighted the need for safety management systems, safety training, and safety culture to ensure safety in the project.

16. Lingard and Holmes (2016) provides a comprehensive review of safety management in construction, focusing on policies, practices, and research. The authors examine a wide range of literature to identify key themes and trends in safety management, including regulatory frameworks, safety culture, risk assessment, safety training, and communication. The review highlights the evolution of safety management practices over time and discusses the challenges and opportunities for improving safety performance in construction projects. The paper contributes to the field by offering a consolidated overview of safety management, providing a foundation for future research and guiding the development of effective safety management strategies.

17. Mohan et al. (2019) conducted a study on safety management in EPC contracts in the Indian construction industry. The study identified several safety issues, such as inadequate safety regulations, lack of safety culture, and poor safety performance. The authors emphasized the importance of safety leadership, safety culture, safety management systems, and safety training in ensuring safety in EPC projects. The study also highlighted the need for effective communication and coordination among project stakeholders to ensure safety in the project.

18. Singh and Bajaj (2019) conducted a study on safety management in EPC contracts in the Indian power sector. The study identified several safety issues, such as inadequate safety regulations, lack of safety culture, and poor safety performance. The authors emphasized the importance of safety leadership, safety culture, safety management systems, and safety training in ensuring safety in EPC projects. The study also highlighted the need for effective communication and coordination among project stakeholders to ensure safety in the project.

19. Sharma et al. (2018) conducted a study on risk management in EPC contracts in the Indian construction industry. The study identified several risk factors, such as inadequate planning, poor project management, and lack of safety measures. The authors emphasized the importance of risk identification, assessment, and mitigation in EPC projects. The study also highlighted the need for safety management systems, safety training, and safety culture to ensure safety in the project.

4 Proposed Work:

Objectives:

1. To Investigate and understand the Significance of creating a true risk management culture within the organization.
2. To realize usually Cost, safety, quality, environmental performance, community relations and minimizing operational expenditure
3. To Provide a Risk Management Model to assist EPC contractors to manage project risks in a Structured and Integrated manner
4. To develop the decision support tool and its processes, features and management strategy.
5. To improve future research opportunities

5 Methodology:

To achieve the objectives of this study, the following methodology is adopted.

1. Review the past literature to find the gap between the existing method and other method for project management & its risk of failure.
2. Investigating the significance of creating a true risk management culture within the organization.
3. Data collection and analysis of questionnaire for risk identification within construction industry
4. Realize usually Cost, safety, quality, environmental performance, community relations and minimizing operational expenditure
5. Provide a Risk Management Model to assist EPC contractors to manage project risks in a Structured and Integrated manner
6. Develop the decision support tool and its processes, features and management strategy and improve future research opportunities

6 CONCLUSIONS

As the nation under study is an emerging economy, there are proposals for several construction projects likely to come up in the future. This study can be used as an aid to plan for the quantitative risk management for these projects. An integrated decision support system for projects can also be developed based on the risk management model. As the concept is generic, we can extend the concept to several other types of complex infrastructure projects like highways, underground corridor metro rail projects, airports, bridges, nuclear, thermal and hydro power plants and other forms of mass rapid transit system (MRTS) projects. The potentiality of insurance as a risk mitigation tool should also be explored.

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