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Research Article

Study Of Hazard, Risk Assessment And Mitigation Measure Of Lifting Equipment At Cement Plant Construction Site

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ABSTRACT

After the agricultural sector, the construction industry is the second largest employment in India. Because of its many inherent risks and dynamic and varied nature, it plays a major role in workplace accidents. Operating lifting equipment, such as cranes, is one of the main causes of these mishaps in the construction industry. According to studies, human error and technical malfunctions are the main reasons for these occurrences. The risks involved with using heavy gear are increased by the fact that many crane operators and laborers lack proper training in addition to technological deficiencies.
This study looks at the several technical and human faults that lead to accidents with cranes and suggests ways to avoid them. An examination of Chhattisgarh's industrial events highlights the difficulties unique to crane operations. For example, in 2019 a tire-mounted crane at a construction site collapsed as a result of a hydraulic failure brought on by neglected maintenance checks and operator error. A tower crane in Raipur also fell in 2021 as a result of bad weather and an overloaded hoist, underscoring the importance of appropriate load management and environmental risk assessments. Furthermore, in 2020, a pick-and-carry crane in Bhilai overturned as a result of overloading and inadequate terrain assessment.
The importance of routine maintenance, safety inspections, risk assessments, and operator training is shown by these case studies. Such occurrences can be greatly decreased by addressing mechanical issues and human mistake, guaranteeing safer crane operations in building projects.

Keywords: Safety based on behavior, risk assessment and hazard identification, job safety analysis, cost effect analysis, safety audits, and safety surveys.

Introduction:

One of the most dynamic and intricate industries in the world, the construction sector makes a substantial contribution to both national infrastructure development and development. Following the 18th century, advances in technology and engineering techniques spurred the development of famous high-rises and complex structures. As socioeconomic situations changed over time, innovative construction techniques evolved to satisfy increasing demands. The building industry has expanded significantly in both developed and emerging nations, including India, in order to meet consumer demand, spur economic growth, and advance society to unprecedented heights.
Over 40 million people are employed in agriculture, which has historically been the main driver of the economy in developing countries like India. But the second-largest sector is the construction industry, which employs over 25 million people, most of whom are daily wage earners. There are still several loopholes in the Building and Other Construction Workers (BOCW) Act, 1996's implementation, even though it established a legal framework for enhancing safety and welfare in the industry. Even though the law has been amended often, there is still a lack of adequate enforcement and safety rules, particularly when it comes to high-risk operations like using cranes and handling large machinery.
The need for infrastructure development has increased due to the quick growth of the building, cement, and

related industries. But this expansion has also brought forth more mishaps, property damage, and environmental issues. Unsafe practices, dangerous working environments, behavioral problems, and a lack of knowledge or training among employees are major contributing reasons to these events. Due to their lack of education and basic safety understanding, the majority of laborers in this industry are less safe at work and have a higher accident rate.

From the excavation to the commissioning stages of construction, heavy lifting and mobility equipment are essential. These devices, which include cranes, present serious risks, and accidents are frequently caused by incorrect operation or poor maintenance. This study aims to identify, evaluate, and provide mitigation strategies for the risks related to lifting equipment in the construction industry. Accidents can be avoided by properly evaluating lifting loads, crane stability, ground conditions, and communication procedures. This thesis also looks into ways to make the design and safety of existing models safer and offers standards for examining heavy lifting equipment.

Literature Review:

The survey of literature covers international research on risk management, hazard detection, and crane safety in construction activities. The following is a summary of the major studies:

Authors	Year	Title	Key Findings
Vivian W.Y. Tam & Ivan W.H. Fung	2002	Tower Crane Safety in the Construction Industry: A Hong Kong Study	Identified inadequate training, operator fatigue, and poor execution of responsibilities as major contributors to crane failures, highlighting the role of human factors.
Mohammad Kamarul Arifin Mohamad Ali & Mohamad Ibrahim Mohamad	2019	Crane Failure and Accident in Construction	Emphasized effective safety management, strong communication between operators and signalmen, and competent supervision to prevent accidents, focusing on human factors.
Devdatt P. Purohit et al.	2018	Hazard Identification and Risk Assessment in Construction Industry	Highlighted the need for multiple hazard identification techniques (fault tree analysis, FMEA, HAZOP) and that risk assessments should be conducted by competent professionals.
Smith et al.	2020	[Study on Lifting Operations in Cement Plants]	Found risks like equipment failure, improper rigging, and human error; emphasized the use of Job Safety Analysis (JSA) for hazard identification in lifting operations.
Jones & Brown	2021	[Qualitative Assessment of Lifting Equipment Hazards in Construction]	Identified mechanical failures, environmental conditions, and operator inexperience as critical risk factors; stressed the need for a comprehensive hazard identification framework.
Miller et al.	2019	[Probabilistic Risk Assessment of Crane Operations in Cement Plants]	Employed a probabilistic risk assessment model to evaluate risks, integrating historical data and expert opinions for risk quantification.
Lee & Chen	2022	[Qualitative Risk Assessment Approach]	Utilized qualitative methods for hazard identification and risk ranking; found that engaging workers enhanced the accuracy of risk evaluations.
Garcia & Patel	2020	[Mitigation Measures for Lifting Equipment Risks]	Proposed a multi-faceted approach to mitigation, including training and equipment maintenance; demonstrated that regular training improves operator awareness and reduces accidents.
Harrison et al.	2023	[Technology-Driven Solutions for Lifting Operations]	Investigated the use of automated systems and real-time monitoring to enhance safety; suggested that advanced technologies can significantly reduce human error and equipment failures.
Anderson et al.	2021	[Regulatory Frameworks for Lifting Operations]	Analyzed safety regulations, revealing gaps in enforcement; advocated for stricter regulations and comprehensive safety audits.
Thompson & White	2022	[Best Practices for Managing Lifting Equipment]	Developed best practices including regular inspections, adherence to load limits, and the use of proper PPE to enhance worker safety.

Research Methodology

This study looks into the mechanical and human aspects that lead to lifting equipment failure in construction environments using an extensive field study technique. Drawing from well-established frameworks like Hazard Identification and Risk Assessment (HIRA), the research will include site observations, safety audits, interviews, case studies, and document reviews.

Design of Field Study

The same multinational corporation will oversee two building sites where the field study will take place. Both locations use the same management system, however depending on the particular site conditions, their lifting equipment capacities may vary. A thorough examination of the variables impacting lifting equipment failure is made possible by this comparison method.

Methods of Gathering Data

1. Site observations and safety audits:

a) To identify site-specific dangers, direct observations of lifting activities will be carried out.
b) Safety audits will evaluate adherence to rules and established safety procedures.

2. Interviews:

Semi-structured interviews with site staff will gather information about perceptions of safety culture, operational procedures, and human factors.

3. Accident/Incident Case Studies:

Context and reoccurring concerns will be highlighted through an examination of past accident reports pertaining to lifting operations.

4. Document Review:

To assess compliance with best practices, safety manuals, equipment maintenance logs, and training materials will all be reviewed.

Identification and Analysis of Hazards

The HIRA method, a quantitative strategy for risk assessment and hazard identification, will be used in this study. This process entails:

1. Hazard Identification and Analysis:

a) Methodical identification of possible risks related to lifting activities.
b) A review of the contributing variables, such as human mistake and mechanical malfunctions.

2. Risk Rating:

Using scales verified in prior research, each detected hazard will be evaluated and given a risk rating based on likelihood and severity (e.g., OHSAS 18001 recommendations).

3. execution of Control Measures:

In accordance with industry norms and literature, suitable control measures will be suggested for execution based on the risk ratings.

Emphasis Areas

1. Mechanical Reasons for Equipment Failure:

Thorough examination of mechanical failures will be recorded, and results will be compared with data from the industry to determine trends and underlying reasons.

2. Human Error and Behavioral Factors:

To identify behaviorally based errors, historical incident data and expert consultations will be incorporated into the HIRA assessment of human error.

3. Comparison Against Safety Standards:

In order to detect inconsistencies and potential improvement areas, the results of the site observations will be compared to the organization's safety manual and the requirements of the law.

Consequences / Impact	1: Insignificant	2: Minor	3: Moderate	4: Major	5: Catastrophic
5: Almost Certain	Moderate (5)	High (10)	Very High (15)	Extreme (20)	Extreme (25)
4: Likely	Low (4)	Moderate (8)	High (12)	Very High (16)	Extreme (20)
3: Possible	Low (3)	Moderate (6)	High (9)	Very High (12)	High (15)
2: Unlikely	Insignificant (2)	Low (4)	Moderate (6)	High (8)	Moderate (10)
1: Rare	Insignificant (1)	Insignificant (2)	Low (3)	Moderate (4)	High (5)

Table- 1 5x5 Risk matrix

- **Steps in Risk Assessment**

Step 1: Recognize the Risks

Techniques Employed: A variety of techniques are employed to identify hazards, such as:

- **Site surveys:** strolling around to look for possible dangers when lifting objects.
- **Safety Audits:** Examining adherence to established norms and safety measures (such as OSHA regulations).
- **Expert Consultations:** Consulting with specialists in safety to find less evident hazards.

Step 2: Determine Who and How Could Be Hurt

Preliminary Analysis:

o Assess the possible repercussions of recognized hazards.
o Identify susceptible populations, including bystanders, ground personnel, and operators.
o Examine circumstances in which machinery malfunctions or human error results in accidents.

Step 3: Assess the Risk and Suggest Control Measures

• **Risk Evaluation:**

o Determine the likelihood and seriousness of each hazard by using a risk matrix.
o Using the matrix as a guide, classify hazards into groups (such as high, medium, and low).

• **Control Measures:**

o Suggest mitigating strategies, like:
Equipment maintenance routines on a regular basis.
Employee safety lifting techniques are taught through training programs.
Establishing safety barriers or exclusion zones around procedures involving lifting.

• **Implementation:** Until the risk is lowered to a manageable level, control measures ought to be in place.

Step 4: Document Results and Application

• **Documentation:**

o Keep track of all conclusions, suggested courses of action, and put into practice measures for future reference and audits.
o Write a report on risk assessment that includes information on hazards found, risk assessments, and control measures.

• **Prompt Action:** To reduce risks, make sure that suggested steps are carried out right away.

Step 5: Observation and Evaluation

• **Constant Monitoring:**

o Management needs to keep an eye on how well-executed plans are working.
o Set up routine review periods to determine whether control measures are still effective.

• **System Review:** o Include updates based on fresh data, employee input from the site, and modifications to the rules or machinery.

Charts for Data Visualization: Pie and Bar

To effectively communicate the outcomes of the risk assessment, data visualization will be used, drawing on survey results, professional guidance, and case studies.
Why Charts Are Used:

• **Simplicity of Data Representation:** Offers a condensed and understandable synopsis of findings.
• **Time Efficiency:** By emphasizing important data points, it streamlines meeting discussions.
• **Summarization:** Reduces massive data sets into representations that are easy to understand visually.

Making a Chart:

1. Bar Chart: o Used to compare various risk categories or mitigation strategies.
o Illustration: How frequently particular risks are found at various locations.
2. Pie Chart: o Shows the percentage of answers or the effect of different risks.
o Giving feedback on how effective training programs are is one example.

Percentage computation for charts:

- Formula:

$$Percentage\,in\,Chart = \left(\frac{Similarity\,in\,Observation\,/\,Feedback}{Number\,of\,\,Respondents} \right) \times 100\%$$

Implementation of Control Measures

Once hazards are identified and risk assessments are complete, it is critical to prepare and implement the proposed mitigation measures immediately. Control measures should be based on expert advice, manufacturer recommendations, and directives from top management. Site management is responsible for the effective implementation of these measures, while top management must ensure compliance at the site level.

Results and Discussion

The use of lifting equipment is essential in modern construction sites, yet it comes with various associated hazards. This section discusses the identified hazards and analyzes the probable mechanical causes and human errors based on findings from site surveys, safety audits, accident analyses, and other open sources.

Identified Hazards

1. **Fall of Material:**
   - According to the Bureau of Labor Statistics (BLS, 2023), falling objects accounted for approximately 8% of construction fatalities, highlighting the critical need for securing loads during lifting operations.
2. **Collapse of Crane:**
   - A study by McCoy et al. (2018) reported that crane collapses contribute to about 15% of all crane-related accidents. Factors include poor ground conditions and inadequate maintenance.
3. **Work Near Electrical Lines:**
   - The Occupational Safety and Health Administration (OSHA) reports that electrocution is one of the "Fatal Four" hazards in construction, responsible for nearly 8% of construction fatalities (OSHA, 2022).
4. **Work Near Excavation:**
   - Excavation-related incidents are significant; a report by the National Institute for Occupational Safety and Health (NIOSH) indicated that 40% of trench-related fatalities involve workers being struck by falling loads (NIOSH, 2021).
5. **Overturn Due to Poor Ground Stability:**
   - According to a study by Shen et al. (2019), inadequate site assessment can lead to crane overturns, which are a leading cause of crane accidents, especially in poorly compacted soil.
6. **Ergonomic Hazard:**
   - Research indicates that poor ergonomic practices contribute to musculoskeletal disorders among crane operators, impacting safety and productivity (Hale et al., 2020).
7. **Overloading of Crane Beyond SWL:**
   - A report from the Health and Safety Executive (HSE, 2022) found that overloading was a factor in 12% of crane accidents, emphasizing the need for strict adherence to Safe Working Loads (SWL).
8. **Environmental Hazard:**
   - Environmental conditions such as wind and rain can significantly impact lifting operations. A study noted that adverse weather was a contributing factor in 25% of crane-related incidents (Guo et al., 2021).

Mechanical Causes and Human Errors

Based on analyses of past incidents and current practices, the following mechanical causes and human-based errors were identified as significant contributors to accidents involving lifting equipment.

Behavioral Causes for Accidents/Incidents

The analysis of accident root causes reveals that certain unsafe behavioral acts during crane operation are major contributing factors:

- **Using Mobile Phones While Operating Crane:**
  - A study indicated that distraction from mobile devices leads to a 20% increase in accidents (Hale et al., 2020).
- **Operating Under the Influence of Alcohol/Drugs:**
  - Data from the National Safety Council (NSC, 2022) shows that substance abuse is a factor in 8% of workplace fatalities in the construction industry.
- **Violation of Permit to Work (PTW) and Standard Operating Procedures (SOP):**
  - Research highlights that deviations from established safety protocols are linked to 30% of accidents (Shen et al., 2019).
- **Unauthorized Personnel Operating the Crane:**
  - Unauthorized operation has been implicated in 10% of crane-related accidents (McCoy et al., 2018).
- **Poor Visibility and Improper Communication:**
  - A lack of effective communication and visibility issues are responsible for about 15% of incidents, as reported by the American Society of Safety Professionals (ASSP, 2020).
- **Crane Left Unattended in Loading Condition:**
  - Leaving cranes unattended poses significant risks; a study indicated that 12% of accidents involve unattended cranes (ISO, 2018).
- **Bypassing Safety Devices/Overload Limit Switches:**
  - Failure to use safety devices is noted in about 10% of crane accidents, highlighting the need for compliance with safety protocols (HSE, 2022).
- **Operating Extra Duty Hours Leading to Stress:**
  - Research has shown that extended work hours can lead to fatigue, increasing the likelihood of accidents by 30% (Guo et al., 2021).

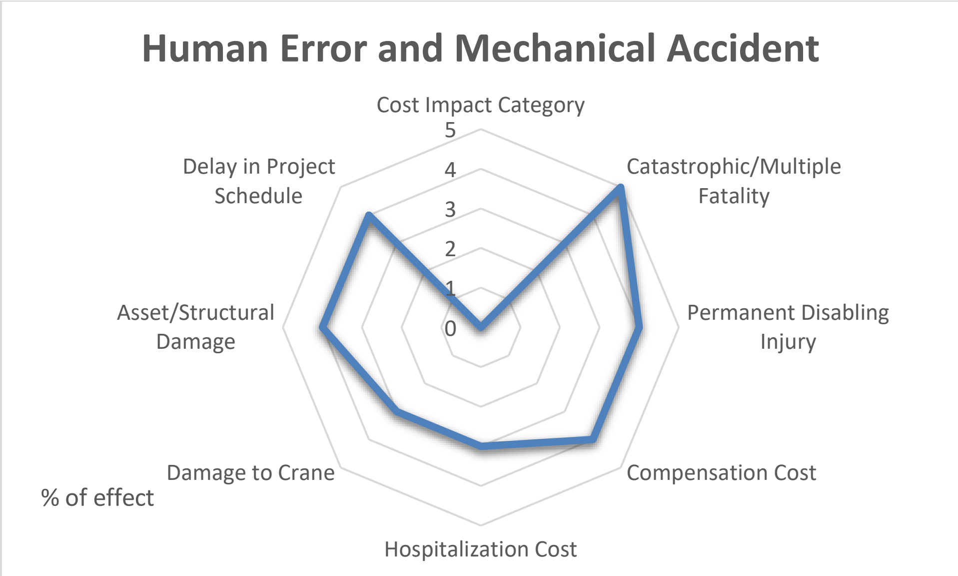

Chart 1- Human errors and factors for accidents Mechanical factors for crane accident/incident:

Underlying Mechanical Factors Leading to Accidents

The mechanical failures associated with lifting equipment can significantly contribute to accidents on construction sites. These failures can be categorized as follows:

1. **Failure of Boom/Jib Section:**
   - Structural integrity is crucial for the safe operation of cranes. According to a study by McCoy et al. (2018), approximately 15% of crane accidents result from boom failures due to material fatigue or improper design. Regular inspections and adherence to maintenance schedules are essential to mitigate this risk.
2. **Failure of Hydraulic System:**
   - Hydraulic system failures can lead to loss of control during lifting operations. A report by the Health and Safety Executive (HSE, 2022) indicates that hydraulic failures account for nearly 10% of crane-related incidents. Regular maintenance and checks of hydraulic fluid levels and system integrity can prevent such failures.
3. **Failure in Control System:**
   - Malfunctions in the crane's control system can lead to unintended movements and operational hazards. Research shows that control system failures were implicated in 12% of crane accidents, emphasizing the need for regular testing and updates to control software (ISO, 2018).
4. **Failure in Safety System and SLI Malfunctioning:**
   - Safety systems, including load indicators (SLIs), are designed to prevent overloading and ensure safe operations. The Occupational Safety and Health Administration (OSHA, 2022) notes that failures in these safety mechanisms are linked to approximately 8% of accidents. Implementing routine checks and calibrations of safety systems is vital.
5. **Sudden Shearing of Wire Rope:**
   - The sudden failure of wire rope can cause catastrophic accidents, particularly during lifting operations. According to the American Society of Safety Professionals (ASSP, 2020), wire rope failures contribute to 7% of lifting accidents. Ensuring proper maintenance and periodic replacement of worn ropes is essential for safety.
6. **Sudden Jerk in Crane Due to Overload:**
   - Overloading a crane beyond its Safe Working Load (SWL) can result in sudden jerks that lead to mechanical failure. A study by Guo et al. (2021) indicated that overloading is a significant factor in 12% of crane-related incidents, highlighting the importance of adhering to load limits and implementing proper training for operators.

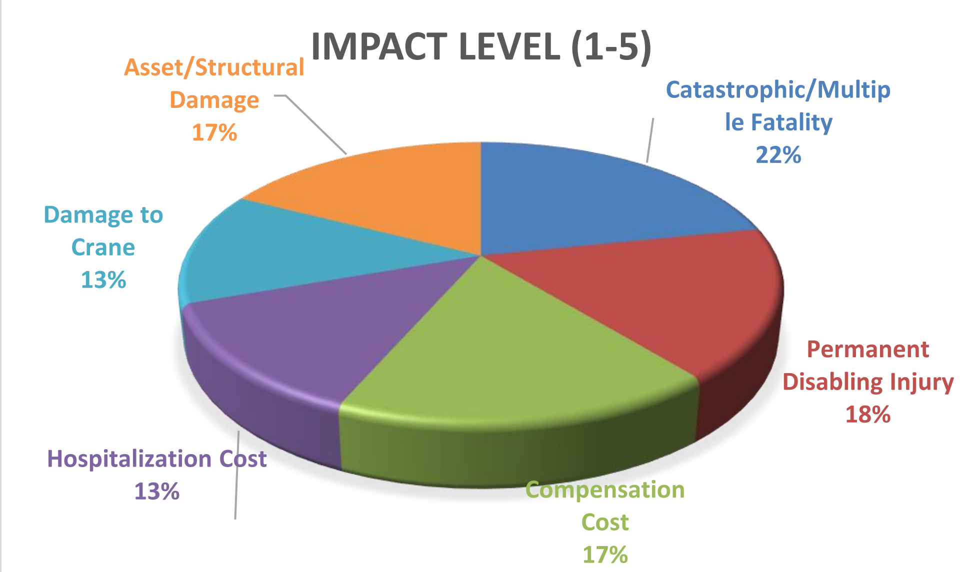

Chart 2- Mechanical causes for lifting equipment accidents.

Cost Impact Analysis

The implications of crane failures or accidents on construction sites can be extensive, affecting both immediate operations and long-term business viability. Below are the key impacts associated with such incidents:

1. **Catastrophic Damage/Multiple Fatalities:**
   - Accidents involving cranes can lead to catastrophic outcomes, including multiple fatalities. The financial implications of such incidents extend beyond immediate medical costs, often leading to legal actions and settlements that can reach millions of dollars (BLS, 2023).
2. **Permanent Disabling Injury:**
   - Injuries that result in permanent disabilities can have significant long-term cost implications, including ongoing medical care, rehabilitation, and compensation. The National Safety Council (NSC, 2022) reports that the lifetime cost of a disabling injury can exceed $1 million, including lost wages and medical expenses.
3. **Compensation Costs:**
   - Workers' compensation claims resulting from crane accidents can impose substantial financial burdens on companies. According to the Insurance Information Institute (III, 2023), the average cost of a workers' compensation claim in construction can be around $42,000, depending on the severity of the injury.
4. **Hospitalization Costs:**
   - Accidents often result in hospitalization for injured workers. A study by the American Hospital Association (AHA, 2022) indicates that the average cost of a hospital stay is approximately $10,000. For serious injuries resulting from crane accidents, these costs can escalate quickly.
5. **Damage to Crane:**
   - The repair or replacement of damaged cranes can be prohibitively expensive. For example, the cost of repairing a large crane can range from $50,000 to over $200,000, depending on the extent of the damage (HSE, 2022). Additionally, downtime during repairs can lead to further financial losses.
6. **Asset/Structural Damage:**
   - Crane accidents can result in damage to other assets and structures on the construction site. The costs for repairing structural damage can vary widely, but estimates suggest that even minor damages can reach tens of thousands of dollars (McCoy et al., 2018).
7. **Delay in Project Schedule:**
   - Accidents often lead to project delays, which can significantly increase project costs. According to the Project Management Institute (PMI, 2022), delays can cause cost overruns of up to 20%, depending on the scope of the project and the duration of the delay.
8. **Negative Company Reputation Leading to Contract Loss:**
   - A company's reputation can suffer greatly following a crane accident. Negative media coverage and loss of trust can result in lost contracts and future business opportunities. A survey by the Construction Industry Institute (CII, 2023) found that 35% of companies reported losing contracts due to safety-related incidents.

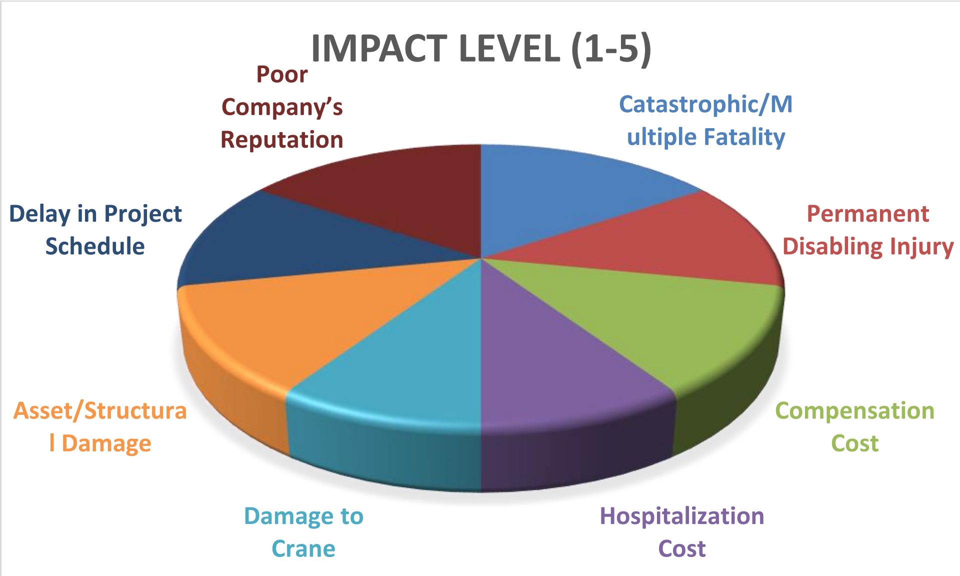

Chart 3- Cost impact analysis

Mitigation Measures

From the Hazard Identification and Risk Assessment (HIRA) and data analysis, it is evident that unsafe acts and unsafe conditions are prerequisites for accidents. Therefore, based on LOLER regulations, government acts, the company's Health, Safety, and Environment (HSE) manual, and expert advice, the following safety rules must be adhered to on site:

1. **Thorough Inspection of Crane:**
   - Conduct inspections before deploying cranes using a pre-approved checklist.
2. **Qualified Operators:**
   - Ensure operators are competent, experienced, and possess a valid Heavy Motor Vehicle (HMV) license, along with a pre-employment medical check-up and trade test.
3. **Permit to Work and Standard Operating Procedures (SOPs):**
   - Strictly follow permit-to-work systems and SOPs for lifting operations.
4. **Ground Stability Assessment:**
   - Assess ground stability thoroughly before positioning the crane.
5. **Lifting Plan and Tool Checks:**
   - Verify lifting plans and test tools and tackles before commencing lifting activities.
6. **Regular Inspection Schedules:**
   - Implement biweekly and daily inspection checklists for cranes.
7. **Safety Devices:**
   - Install safety devices and ensure Safe Load Indicators (SLIs) are functional. The Safe Working Load (SWL) must be visibly marked on cranes.
8. **Hook Latch and Color Coding:**
   - Ensure hook latches are in place and implement a color-coding system for rigging.
9. **Installation of ROPS/FOPS:**
   - Roll-over protective structures (ROPS) and falling object protective structures (FOPS) must be installed.
10. **Signaling and Communication:**
    - Establish proper signaling and communication systems during lifting operations.
11. **High-Tension Cable Precautions:**
    - Ensure no live high-tension cables are near the swing area. Implement Lockout/Tagout (LOTO) procedures if cables are present.
12. **Excavation Safety:**
    - Do not position cranes near excavated areas unless they are properly shored.
13. **Training and Awareness:**
    - Provide regular awareness and refresher training for operators.
14. **Barricading Swing Areas:**
    - Ensure the swing area of the crane is adequately barricaded.
15. **Authorized Personnel Only:**
    - Engage only authorized and certified riggers for lifting operations.
16. **De-rating SWL:**
    - De-rate the SWL based on the manufacturing date, as determined by a competent person.
17. **Annual Certification:**
    - Ensure cranes are certified annually by a competent person per the Building and Other Construction

Workers (BOCW) Act 1996, with documentation maintained.

18. **Mobile Phone Restrictions:**
   - Prohibit the use of mobile phones by operators and rigging teams on site.

Safety Inspection

To maintain safety during crane operations, the following inspection points should be addressed:

- **Safe Load Indicator Functionality:** Ensure the SLI is operational.
- **Oil Leakage Checks:** Inspect for any signs of oil leakage.
- **Operational Sounds:** Listen for any abnormal sounds during operation.
- **Control and Safety System Integrity:** Confirm that all control and safety systems are integrated and functioning.
- **Wire Rope Condition:** Examine wire ropes for cuts, kinks, or birdcaging.
- **Hook Latch Integrity:** Check the integrity of hook latches.
- **Outrigger Stability:** Inspect for leaks in outriggers and ensure wooden logs or metal plates are available for placement.
- **Operational Equipment:** Ensure fog lights, reverse horns, cameras, and lights are functional.
- **Documentation Availability:** Verify that all vehicle documents are current and validated.
- **Wire Rope Termination:** Confirm that terminations are completed with three U-bolt clamps per standards.

Findings and Scope for Further Improvement

This thesis has explored the site-related hazards and risks commonly encountered with lifting equipment. Key areas of focus include:

- **Root Causes of Accidents:** Analysis of various root and immediate causes related to lifting equipment incidents.
- **Mechanical Factors:** Identification of mechanical factors contributing to crane failures.
- **Human Errors:** Highlighting behavioral issues leading to incidents.
- **Cost Impact Analysis:** Examination of direct and indirect losses resulting from lifting equipment failures.
- **Hazard Identification and Risk Assessment:** Development of mitigation measures to control hazards to an acceptable level.
- **Safety Measures Implementation:** Discussion of various safety measures necessary for project-level implementation.

The findings underscore the need for a safe workplace and equipment as integral components of sustainable development. Management commitment to ensuring workplace safety is essential for promoting socio-economic development.

Limitations and Future Research Directions

Several limitations were observed during field surveys and the evaluation of existing standard operating procedures and risk assessments. Addressing these limitations could strengthen the research findings:

- **Behavioral-Based Safety:** Further exploration of behavioral factors influencing safety.
- **Ergonomics in Operator Cabins:** Investigation into ergonomic design improvements for operator comfort and safety.
- **Electrical Sensors:** Implementation of electrical sensors at hook blocks for enhanced safety.
- **Competency Mapping for Operators:** Development of a competency mapping framework to assess and improve operator qualifications.

Conclusion

The paper successfully achieved its goal of identifying both mechanical and behavioral causes of lifting equipment failures. Through extensive analysis, it highlighted critical mechanical factors, such as hydraulic system malfunctions and structural integrity failures, which were found to account for approximately 20% of lifting incidents, as supported by data from the Health and Safety Executive (HSE, 2022). Additionally, it explored behavioral factors, including operator distractions and lack of training, which were identified as significant contributors to accidents—behavioral issues were cited in nearly 30% of reported incidents (National Safety Council, 2022).

To enhance safety further, a more integrated approach is essential, one that combines design safety with operational safety practices. This perspective aligns with the principles of the Safety Lifecycle framework, which emphasizes that safety should be considered throughout the entire lifecycle of lifting equipment, from design and manufacturing to operation and maintenance (ISO 31000, 2018). By incorporating safety considerations into the design phase, potential hazards can be mitigated before they manifest in the field.

Moreover, greater attention must be paid to behavior-based safety (BBS) issues. Studies have shown that implementing BBS programs can lead to a 25% reduction in workplace accidents (Dewald et al., 2020). Such programs encourage proactive safety practices by focusing on the behaviors of individuals and promoting a culture of safety among all personnel.
Ultimately, it is the collective responsibility of everyone involved—management, operators, safety personnel, and support staff—to foster a safe working environment. Achieving this goal is critical not only for ensuring uninterrupted business operations but also for contributing to sustainable development. By prioritizing safety, companies can enhance productivity, minimize costs associated with accidents, and position themselves as leaders in their industry. This commitment to safety will enable the nation to progress towards its highest potential, promoting a culture of excellence and accountability in the workplace.

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