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Hazard Identification And Risk Assessment On Heavy Lifting Machines In Metro Construction

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***Abstract*— II.** The study found that heavy lifting machines in metro construction pose significant hazards to workers, including the risk of falling objects, machine entanglement, and electrical hazards. The process of risk assessment revealed that some hazards had a high risk level, indicating the need for immediate action to control or eliminate these hazards. The project discusses various control and mitigation measures which can be implemented to reduce the level of risk which is identified hazards. The study highlights the importance of regular hazard identification and risk assessment activities in the Metro Rail construction to ensure the worker's safety. This study provides the best control measures which can be implemented to control the specific hazard during the heavy lifting activities in metro construction.

Keywords—Hazard identification and risk assessment, Risk Matrix, Metro rail Construction, Heavy Lifting Machines, Crane Safety.

I. INTRODUCTION

Moving large heavy loads is crucial in today's construction industries. Heavy lifting machines are powerful equipment designed to move, lift, and transport heavy objects, materials, and machinery within a worksite or construction site. Crane are the most important and widely used machines in construction field. Every construction site requires some type of lifting equipment to move and carry weight around.

There are many types of heavy lifting machines used in Metro Constructions, each designed for specific tasks and applications. Mobile cranes are versatile cranes which can be moved easily around a job site. It can be provided with different attachments, such as a telescopic boom or a lattice boom, to lift and move materials of different shapes and sizes. Crawler cranes are large cranes that are mounted on tracks or crawlers, making them highly manoeuvrable and able to move over rough terrain. Tower cranes find frequent use in the construction of tall buildings. They are fixed to the ground and offer exceptional height and lifting capacity.

II. PROCESS

Metro rail construction process involves a series of intricate steps to ensure successful development of an efficient urban transportation system. One of major aspects of this construction process is to use heavy lifting machines. Heavy lifting machines are instrumental in handling large and heavy materials, equipment, and structures.

III. OBJECTIVE AND METHODOLOGY

A. Objective of the Project

- Hazards associated with Heavy lifting machines used in metro construction.
- To Identify potential risks associated with crane operations and evaluate the severity and likelihood of occurrence.
- To provide Control Measures to ensure the risk rating is in minimum and acceptable level.

B. Problem identification

Crane accidents occur equally at construction sites and factories or plants, with nearly 70% of crane accident fatalities occurring in heavy and civil engineering and construction industries. Heavy Lifting machine accidents, including fatalities and serious injuries, will occur if machines are not inspected, maintained and used properly. However crane accidents continue to happen and there remain significant safety issues to be considered, both for the operators of the cranes and for those working near cranes if the technical failure of these equipment's and technical process of operation are not known clearly, this may lead to the occupational accident like toppling and upsetting of crane, as the crane operators and contractors do not strictly comply with technical standard and bypassing the safety devices when using heavy lifting machines.

C. HIRA Flow Chart

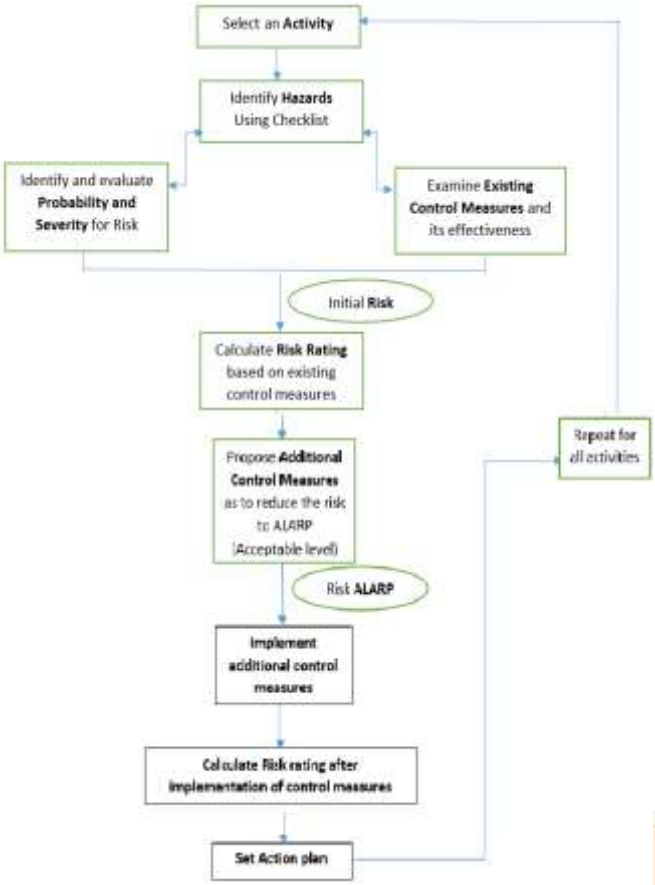

Fig. 1 HIRA Flow Chart

D. Methodology

Hazard Identification and Risk Assessment is a crucial process in ensuring the safety of heavy lifting machines and the personnel operating them. It involves identifying potential hazards, assessing associated risks, and implementing control measures to mitigate those risks. Here's a step-by-step process for conducting a HIRA on heavy lifting machines: The steps involved in Hazard Identification and Risk Assessment are:

1) Selection of Activity: Collect information regarding the specific heavy lifting machine and its intended use. Review equipment manuals, maintenance records, and safety guidelines provided by the manufacturer. Understand the operational environment, including factors like terrain, weather conditions, and proximity to other equipment or structures.

2) Identifying Hazards and Assess Risk: Conduct a thorough inspection of the heavy lifting machine and its surroundings. Identify potential hazards, including mechanical, electrical, and environmental factors. Consider factors such as equipment malfunctions, structural failures, electrical hazards, and operator errors. Evaluate the severity and likelihood of identified hazard. Use a risk matrix or a similar tool to assess level of risk associated with each hazard. Determine the potential consequences of accidents or incidents involving the heavy lifting machine.

3) Develop and Implement Recommended Control Measures: Propose control measures for each identified hazard to reduce or eliminate the associated risks. Control measures may include engineering controls, administrative controls, and personal protective equipment (PPE). Ensure that control measures are feasible and practical for implementation.

4) Review and Monitor: Continuously monitor the heavy lifting machine's operation and the effectiveness of the control measures. Conduct periodic safety audits and inspections. Review incident reports and near-miss incidents to identify any new hazards or potential improvements. Maintain detailed records of the HIRA process, including hazard identification, risk assessments, control measures, and training records.

E. Risk Matrix

Risk matrix is utilized to assess the risk level for each identified hazard. Initially, risk ranking is determined by evaluating the unmitigated risk associated with each hazard. Subsequently, the risk level is reassessed, taking into account the existing prevention and mitigation measures as well as controls in place.

LIKELIHOOD	Very Likely - 5	5	10	15	20	25
	Likely - 4	4	8	12	16	20
	Possible - 3	3	6	9	12	15
	Unlikely - 2	2	4	6	8	10
	Very Unlikely - 1	1	2	3	4	5
		1	2	3	4	5
		Negligible	Slight	Moderate	High	Very High
		SEVERITY				

Risk	Risk Level	Action
1 to 6	Low Risk	May be acceptable but review task to see if risk can be reduced further
8 to 12	Medium Risk	Task should only be undertaken with appropriate management authorization after consultation with specialist personnel
15 to 25	High Risk	Task must not proceed. It should be redefined or further control Measures put in place to reduce risk.

Fig. 2 Risk Matrix

In the event that risk falls within the Green zone, it is deemed acceptable, and there is no need for additional actions. When the risk resides within the Yellow region, it falls within tolerable limits, but it must be demonstrated to achieve the lowest possible risk level through recommended actions. If the risk remains in the Red region, it is regarded as unacceptable, and immediate corrective action is required. The HIRA Review team will discuss potential actions, as applicable, to address hazards with medium to high-risk ratings.

IV. Data Collection and Analysis

A. Hazard Identification

Checklists, Inspection and Standard Procedures can be employed for the hazard identification. Risks involved during the lifting activity. This checklist provides the basic requirements for safe operations of a crane.

B. Risk assessment

1) Selection of Lifting Activity: Crane Operation Movement, Lifting, Lowering, Extending.

2) Hazards: Overloading during Loading and Unloading of stacks, Rigging, Packing.

Consequences: Slings, shackles, lifting points used beyond SWL causing load to fall. Incorrect/unstable loading set up, load will fall or slip. Poor rigging of load causing it to fall. Hand & finger injuries when handing slinging equipment. Wind taking control of load causing injuries and damage. Person falling from height while swinging load.

Existing control measures: Communications between designated banks man and crane operator. Fall arrest

system for rigger Equipment testing & certification system. Crane lifting procedures specifying maximum wind speed for work to be carried out 11m/s. Only essential persons to enter lifting and load movement zone. Wind speed restrictions procedure when carrying out lifting operations.

Calculating Risk Rating: With the existing control measures, Risk Rating can be calculated by Probability and Severity. Whereas, Probability is very likely to happen, which is 5 and Severity rate is High, which is 4. So, by multiplying Probability and Severity we can 20, which is classified as high risk, the activity must not proceed further. So the control measures are to redefine which reduces the Risk Rating.

Implementing additional control measures: Certified full body harness and fall arrest system to be employed for slinging of loads with lifting points in excess of 2m above ground level. Wind speed to be assessed and monitored before and during lifting operations using anemometer. The containers which are lifted is to be assessed for balance High level of supervision throughout operation.

Calculating Risk Rating after Implementing Recommended Control Measures: Implementing additional recommended Control measures to reduce risk rating, Lik elihood is Unlikely to happen, which is 2 and Severity rate is Moderate, which can be 3. So, Risk Rating would be 6 which is classified as Low risk and it is acceptable by reviewing the activity to reduce it further.

3) *Hazards:* Workers working during movement of the heavy lifting machines

Consequences: Collision with jib or load causing fatal injury or equipment damage. Over extending jib causing crush injuries & equipment damage. Housing or lowering of jib causing crush injuries & equipment damage

Existing control measures: Trained crane operative. Trained riggers and Trained banks man, permit to work, lifting zone segregated by barriers. Communications between designated banks man and crane operator. Only essential persons to enter/work lifting zone. Designate danger area and dearly mark. Proper use of the load chart.

Calculating Risk Rating: With the existing control measures, Probability is Likely to happen, which is 4 and Severity rate is High, which is 4. So, by multiplying Probability and Severity we can 16, which is categorized as high risk, the activity must not proceed further. So control measures are to redefine which reduces the Risk Rating.

Implementing additional control measures: Banks man clearly identifiable (Reflective vest coat). Close supervision by HSE and Lifting supervisor. All lifts to be authorised by the Competent Person in lifting Operation but as well assessed by the lifting crew to comply lifting and safety standards. For containers, contents to be assessed for balance prior to each lift. Manufacturer' crane safe use requirements and directions to be followed.

Calculating Risk Rating after Implementing Recommended Control Measures: Implementing additional recommended Control measures to reduce risk rating, Likelihood is Unlikely to happen, which is 2 and Severity rate is Moderate, which can be 3. So, Risk Rating would be 6 which is classified as Low risk and it is acceptable by reviewing the activity to reduce it further.

4) *Hazards:* Material Falling while Usage of defective Lifting tools and tackles Slings, Shackles, Eyebolts, Wire Rope

Consequences: Defective slings, shackles chains failing causing load to fall. Failure of fall arrest equipment Slings or shackles or, chains used beyond SWL causing load to fall. Incorrect loading and Misuse of rigging sings attached to container causing it to fall.

Existing control measures: Equipment testing & certification system by a competent person. Trained rigger able to identify any defective equipment. Persons trained to use fall arrest equipment, and able to identify any defective equipment.

Calculating Risk Rating: With the existing control measures, Probability is Likely to happen, which is 4 and Severity rate is High, which is 4. So, by multiplying Probability and Severity we can 16, which is classified as high risk, the activity must not proceed further. So the control measures are to redefine which reduces the Risk Rating.

Implementing additional control measures: Pre-use Visual Inspection to be carried out by the competent rigger before. Proper storage of all the lifting tools and tackles in the storage area. Training given to all the riggers about handling of Lifting tools and tackles. Proper preventive maintenance should be carried out.

Calculating Risk Rating after Implementing Recommended Control Measures: Implementing additional recommended Control measures to reduce risk rating, Likelihood is very Unlikely to happen, which is 1 and Severity rate is Slight, which can be 2. So, Risk Rating would be 2 which is classified as Low risk and it is acceptable by reviewing the activity to reduce it further.

5) *Hazards:* Crane struck by Electrical Hazards

Consequences: This could lead to fatal accident of crane operator or any individual working under crane. High voltage (More than 33kv) causes Electrical Arcing and Fatal injury from exposure due to Electrical Arcing

Existing control measures: Lifting plan and Tool box talk sharing the sequence of lift as mentioned in lifting plan, load chart. Check the calibration of Safe Load indicator prior to lift. Define exclusion zone.

Calculating Risk Rating: With the existing control measures, Probability is Likely to happen, which is 4 and Severity rate is very High, which is 5. So, by multiplying Probability and Severity we can 20, which is classified as high risk, the activity must not proceed further. So the control measures are to redefine which reduces the Risk Rating.

Implementing additional control measures: Check work radius prior to lift see if they tally with the lifting plan, in case of any variation reposition the crane. Perform trial lift (inch the load to check stability and verify the weight of the load with SLI) in alignment with the lift plan. Keep everyone out of the exclusion zone.

Calculating Risk Rating after Implementing Recommended Control Measures: Implementing additional recommended Control measures to reduce the risk rating, Likelihood is Unlikely to happen, which is 2 and Severity rate is Moderate, which can be 2. So, Risk Rating would be 4 which is classified as Low risk and it is acceptable by reviewing the activity to reduce it further.

V. SUGGESTIONS & RECOMMENDATIONS

Based on the findings from the report on Identification of hazards and assessment of risks for heavy lifting machinery in metro construction, several crucial suggestions and recommendations emerge to bolster safety and practices for managing risk. It is imperative to institute comprehensive training and certification programs for all personnel engaged in heavy lifting operations, including crane operators, riggers, and banks men, to ensure they possess the necessary skills and qualifications. Regular equipment inspection and maintenance routines must be established, with a particular focus on pre-use checks by competent individuals to promptly detect and address any defective machinery. Stricter adherence to safe load limits, including regular calibration and verification of load indicators, is vital, supported by clear communication protocols between banks men and crane operators to prevent overloading incidents.

The continued use of risk matrix for assessing and prioritizing risks is recommended, with a commitment to regularly reviewing and updating the risk assessment process. For implementing it is crucial to consider the recommended control measures for each identified hazard and encompassing engineering, administrative, and personal protective controls as needed. Ongoing monitoring and review of heavy lifting operations, periodic safety audits, and meticulous record-keeping are essential. Specific attention should be paid to mitigating Hazards related to electricity when working in proximity to power lines. Promoting a strong safety culture within the organization, encouraging reporting of near-miss incidents and concerns, and facilitating knowledge sharing within the construction industry will contribute to heightened safety standards. Additionally, integrating both qualitative and quantitative risk assessment methodologies can provide a more comprehensive understanding of risks in heavy lifting operations, ultimately leading to refined risk management strategies. Finally, the regular review and update of safety policies and procedures in line with industry standards and regulations is essential to ensure compliance and enhance safety.

By implementing these recommendations, construction companies can significantly enhance safety practices in heavy lifting operations during metro construction projects, ultimately safeguarding the well-being of their workforce.

VI. CONCLUSION

By carrying out a Risk assessment and implementing the control measures, risk rating is reduced to the acceptable level, this control measures should be carried out continuously till the completion of the project with the same nature of work. If there is any change to the activity the Hazard Identification and Risk Assessment should be carried out according to nature of work, which is compared with the existing control measures.

To conclude, this report provides a Control measures are provided for the metro construction site during heavy lifting operation. The recommendations made in this report Can facilitate necessary changes to increase safety of all persons in the hazardous areas. Further to this report, the safety devices involved in lifting, Levelling of Heavy lifting machines, rigging of heavy load in machines and other causes for failure of the Heavy Lifting machines are going to be considered in the next phase of the project.

Risk management is a thorough and methodical approach for recognizing, assessing, and addressing risks with the aim of attaining project objectives. To effectively and efficiently handle risks, contractors must possess a grasp of their risk-related duties, the conditions surrounding risk events, their risk inclinations, and their capabilities in risk management. qualitative approaches to Risk assessments are more frequently used than quantitative methods. Improvements to the risk management framework for metro construction projects can be realized by incorporating a combination of qualitative and quantitative approaches into the risk analysis process.

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