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Hazard Identification, Risk Assessment and Risk Control (HIRARC) in Lifting Operations: A Case Study of Fall Incident at a High-Rise IBS Construction Project

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Abstract

Tower Crane lifting operations in high-rise Industrialized Building System (IBS) construction projects present significant occupational safety and health risks, particularlya those related to work at height and handling of heavy prefabricated components. Despite the importance of impelementation hazard identification, risk assessment and risk control (HIRARC) in Malaysia crane-related incidents continue to occur indicating potential weaknesses in practical implementation. This study aims to evaluate the effectiveness of HIRARC implementation during lifting operations through a case study of a fall incident involving a signalman during the installation of a Prefabricated Bathroom Unit (PBU) at a high-rise construction site. A qualitative case study approach was used which include reviewing the Method Statement and Job Safety Analysis, conducting semi-structured interviews with workers involved and carrying out site observations after the incident. The results show that even though hazards and control measures were identified in documents, there were major weaknesses in how they were applied on site. These included not following the approved work sequence, using an unstable temporary slab as a work platform, poor supervision and ineffective communication. These weaknesses caused a gap between the planned risk control measures and the actual conditions at the worksite. The study concludes that effective HIRARC implementation in real work settings requires more than written documentation alone; it demands continuous attention, strong supervision, and a high level of safety compliance in daily site activities. The findings offer practical recommendations to improve HIRARC practices and enhance safety performance in IBS lifting operations.

1. Introduction

The construction industry is widely recognized as one of the most hazardous sectors due to the high frequency of high-risk activities, particularly those involving lifting operations at height. In Malaysia, the adoption of the Industrialized Building System (IBS) has significantly transformed construction practices by emphasizing

prefabrication and on-site assembly to enhance productivity and project efficiency. High-rise IBS projects rely extensively on tower cranes to lift and position large prefabricated components such as precast panels, beams, slabs and prefabricated bathroom units (PBUs). Despite the operational advantages offered by IBS, tower crane lifting operations introduce substantial occupational safety and health risks due to heavy loads [1].

Tower crane-related hazards commonly include falling objects, load instability, crane collapse, equipment malfunction and human error. These risks are amplified in high-rise IBS construction where multiple lifting activities occur simultaneously within confined and congested environments. The Department of Occupational Safety and Health (DOSH) consistently reports the construction sector as one of the leading contributors to occupational accidents and fatalities in Malaysia, with falls from height and crane-related incidents among the primary causes [2]. Although safety regulations and documented procedures are in place, the persistence of lifting-related accidents indicates ongoing deficiencies in risk management practices at the site level.

To systematically manage workplace hazards, Malaysian construction sites are required to implement Hazard Identification, Risk Assessment and Risk Control (HIRARC) as outlined by DOSH (2008). HIRARC provides a structured framework for identifying hazards, evaluating risks based on likelihood and severity and applying appropriate control measures according to the hierarchy of controls. As a core component of the Occupational Safety and Health Management System (OSHMS), HIRARC aims to reduce accident rates and improve safety performance. Previous studies have demonstrated that effective HIRARC implementation can significantly enhance safety outcomes in construction environments, particularly in lifting operations when hazards are properly identified and controls are consistently enforced [3].

However, lifting operations in high-rise IBS projects present unique challenges that complicate the effective application of HIRARC. Overhead lifting of large prefabricated components expose workers to struck-by hazards, load swing and unstable working positions, particularly when communication between crane operators, signalmen and ground workers is inadequate [4]. Site constraints in dense urban environments further restrict crane movement and load paths which increasing the likelihood of collisions and unsafe worker positioning [1]. Environmental factors such as strong winds, heavy rainfall and poor visibility have also been identified as significant contributors to crane-related accidents, particularly when lifting operations continue despite adverse conditions [5].

In addition, human and behavioural factors play a critical role in lifting-related incidents. Operator fatigue, miscommunication, inadequate supervision and unsafe work attitudes have been widely reported as contributing factors in crane accidents, especially in fast-paced IBS construction environments where schedule pressure is high [6]. These factors highlight the importance of not only documenting HIRARC but also ensuring that it is clearly communicated, understood and practiced by all personnel involved in lifting operations.

Despite the widespread recognition of HIRARC as an essential risk management tool, existing literature indicates persistent gaps in its practical implementation within high-rise IBS projects. Many studies focus on general construction safety or crane hazards without adequately addressing the site-specific complexities of IBS lifting operations, such as handling large prefabricated elements, constrained workspaces and coordination among multiple trades [7]. Moreover, limited empirical research has examined how documented HIRARC procedures align with actual site practices during lifting operations.

This study addresses these gaps by evaluating the implementation of HIRARC in tower crane lifting operations through a qualitative case study of a fall incident involving a signalman during a PBU installation at a high-rise IBS construction site. By examining documented safety procedures, on-site practices and worker experiences, the study aims to assess the effectiveness of existing hazard identification, risk assessment and control measures, and to identify areas for improvement. The findings are expected to contribute practical insights for strengthening HIRARC implementation and enhancing safety performance in high-rise IBS lifting operations.

2. Methodology

This study adopted a qualitative case study approach to evaluate the implementation of Hazard Identification, Risk Assessment and Risk Control (HIRARC) during tower crane lifting operations in a high-rise Industrialized Building System (IBS) construction project. The case study focused on a fall incident involving a signalman that occurred during the installation of a prefabricated bathroom unit (PBU). A qualitative approach was selected to enable an in-depth examination of real work practices, site conditions and safety management processes that contributed to the incident.

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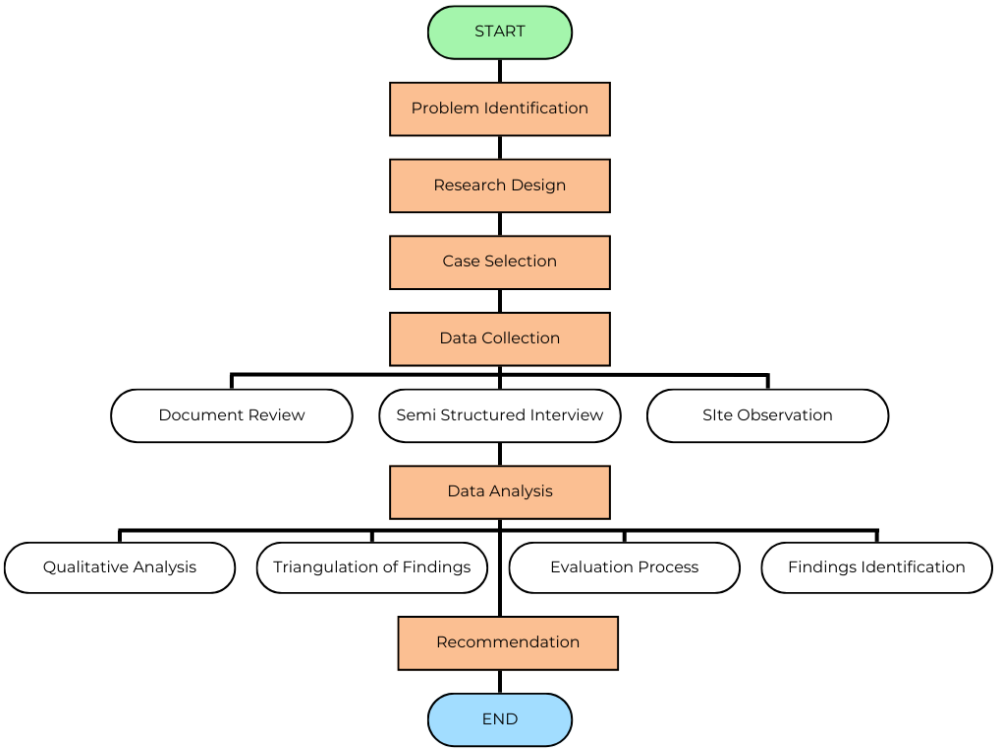

Fig 1 *Methodology Flowchart*

Figure 1 shows the overall research methodology adopted in this study, which follows a systematic and structured qualitative research approach. The process begins with problem identification, where key safety-related issues and research gaps are identified through preliminary observations and literature review. This step ensures that the study addresses a relevant and practical problem within the organizational context.

Next, the research design phase defines the overall methodological approach, including the qualitative strategy, data sources and analytical techniques are used to achieve the research objectives. Following this, case selection is conducted to determine the appropriate organisation, site or participants that represent the study context and provide insights into the research problem.

The data collection stage involves three primary methods including, document review, semi structured interviews and site observations. Document review is used to examine safety policies, procedures, reports and records to understand formal safety practices. Semi-structured interviews give in-dept exploration of participants' perception, experiences and attitudes toward safety practices, while site observations provide direct evidence of actual safety behaviour and implementation at the workplace.

Once data are collected, data analysis is performed using qualitative analysis techniques. This includes qualitative analysis to identify patterns and themes, triangulation of findings to cross-validate data from multiple sources and an evaluation process to assess the effectiveness of existing practices. From this analysis, key issues and strengths are identified through findings identification.

Based on analysed findings, recommendations are developed to address identified gaps and improve safety practices within the organisations. The research process concludes at the end stage, where conclusions are drawn and implications for practice and future research are highlighted.

2.1 Study Site and Case Description

The study was conducted at a selected high-rise IBS construction site in Malaysia that utilized tower cranes for lifting and positioning prefabricated components. The selected case involved a lifting operation at height where a signalman fell between floors during PBU installation. This incident provided a practical basis for assessing the effectiveness of documented HIRARC procedures against actual site practices.

2.2 Data Collection Methods

Data collection was conducted using three complementary methods to support a comprehensive evaluation and enable data triangulation. Key safety documents including the approved Method Statement and Job Safety Analysis (JSA) for IBS Installation, were examined to identify recorded hazards, evaluated risk levels and specified control measures in accordance with the Department of Occupational Safety and Health (DOSH)

HIRARC Guidelines. This document analysis established a reference point for the intended safety controls and risk management measures planned for the lifting activity.

Semi-structured interviews were carried out with personnel who were directly involved in or had relevant knowledge of the lifting operation and the associated fall incident. The interviews explored participants' understanding of work procedures, hazard awareness, communication during lifting activities, supervision practices and adherence to safety requirements, providing insights into actual site practices and perceptions of safety implementation.

In addition, post-incident site observations were conducted to evaluate the physical working environment, including the layout of the lifting area, the condition of the working platform and the implementation of safety controls. The observational data were used to identify inconsistencies between documented procedures and actual site conditions during the lifting operation.

2.3 Data Analysis

The collected data were analyzed using qualitative content analysis. Findings from the document review, interviews and site observations were examined using a triangulation approach to compare documented HIRARC information with actual site practices, in order to identify consistencies and discrepancies in implementation. The identified hazards, risk levels and control measures were reviewed and interpreted based on the Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC) issued by the Department of Occupational Safety and Health (DOSH).

2.4 Ethical Considerations and Rigor

Ethical considerations were addressed by ensuring voluntary participation, maintaining confidentiality of respondents and using data solely for academic purposes. Trustworthiness of the study was enhanced through triangulation of multiple data sources and clear documentation of the analysis process to ensure credibility and dependability.

3. Results

The results of this study highlight clear discrepancies between the documented HIRARC measures and actual work practices during the prefabricated bathroom unit (PBU) lifting operation at the high-rise Industrialized Building System (IBS) construction site.

3.1 Document Review Findings

Review of the approved Method Statement and Job Safety Analysis (JSA) indicated that hazards associated with the PBU lifting operation were formally identified. These hazards included working at height, exposure to falling objects, load movement during lifting, and the risk of worker positioning near suspended loads. Risk levels were assigned in the documentation, and corresponding control measures were specified. The documented controls primarily focused on administrative measures, such as pre-task briefings, supervision requirements, adherence to work sequencing, and the use of personal protective equipment. While the documents acknowledged the need for safe access and working conditions, engineering controls related to stable working platforms and fall prevention systems were limited in detail.

3.2 Interview Findings

Findings from semi-structured interviews with three workers which involved the site supervisor, signalman (victim) and installer (witness), revealed variations in workers' understanding and implementation of the documented safety procedures. Although respondents were generally aware that the lifting operation involved high-risk activities, several workers indicated that instructions provided during pre-task briefings were brief and not consistently reinforced during the operation. Some respondents reported relying on experience and verbal instructions rather than referring to documented procedures. Interviews also revealed that supervision during the lifting activity was not continuous, particularly at critical stages of the operation. Communication between the crane operator, signalman, and ground workers was informal, with limited use of standardized signaling or confirmation protocols.

3.3 Site Observation Findings

Post-incident site observations identified unsafe physical conditions within the lifting area. The working platform used by the signalman during the operation was found to be unstable and not designed as a permanent or protected working surface. No effective fall prevention measures, such as guardrails or safety nets, were observed in the area. In addition, exclusion zones to restrict access beneath the lifting area were either poorly

defined or absent. These observations demonstrated a mismatch between the intended safety controls described in the documentation and the actual site conditions during the lifting operation.

Overall, the results show that although hazards and control measures were documented as part of the HIRARC process, their implementation at the site level was incomplete. Key safety controls related to working at height, supervision, communication, and physical protection were not consistently applied during the lifting operation. These gaps contributed to unsafe working conditions and increased the likelihood of a fall incident during the PBU installation.

4. Discussion

This chapter discussed the study findings within the framework of Hazard Identification, Risk Assessment and Risk Control (HIRARC) to explain the factors contributing to the fall incident involving the signalman during the PBU installation. The findings indicate that although hazards such as working at height, unstable surfaces and crane lifting operations were identified in the Method Statement and Job Safety Analysis, hazard identification was not sufficiently detailed to reflect actual site conditions. Specifically, the hazard associated with workers standing on temporary completed slabs during lifting activities was not clearly identified, which aligns with previous findings that hazard identification often overlooks task and location-specific risks [5][8].

The risk assessment appropriately classified crane lifting and work-at-height activities as high-risk, however, this classification did not translate into effective preventive measures at the operational level. Like earlier studies, the risk assessment appeared to function largely as documentation, with limited practical application on site [4]. The likelihood of slab instability was underestimated, indicating a gap between theoretical risk assessment and real working conditions.

Risk control measures outlined in the Method Statement were weakly implemented, with limited engineering controls and an overreliance on administrative controls and personal protective equipment, contrary to the hierarchy of control principle [9]. Communication and supervision during critical stages of the lifting operation were also ineffective, with no clear stop-work protocol when hazards were identified, reflecting weaknesses noted in previous studies on lifting operations and supervisory authority [10].

Overall, the findings demonstrate that while HIRARC was implemented at a documentation levels, its effectiveness at the operational level was limited. The incident resulted from the combined failure of hazard identification, risk assessment and risk control rather than a single cause, supporting the view that accidents often arise from multiple interacting weaknesses within the HIRARC system [11].

5. Recommendation

The findings highlight that unsafe work sequencing, insufficient hazard identification ineffective communication and weak supervision contributed to unsafe conditions during the lifting activity. Based on these findings, several recommendations are proposed to strengthen HIRARC implementation and prevent similar incidents.

Strict compliance with the approved Method Statement and installation sequence is essential. Precast components should be not used as working platforms unless they are fully concreted, inspected and confirmed structurally stable. Where deviations occur, immediate physical barriers and warning signage must be installed to restrict access and slabs should be concreted promptly to prevent misalignment and instability [9][12][13].

HIRARC processes should be reviewed and updated to ensure hazards are identified in a task and location specific manner, with active involvement from supervisors who directly oversee site activities. Effective handover and structured briefings by engineers and safety officers are necessary to ensure that supervisors understand work procedures, sequencing and associated hazards [10][14].

Communication during high-risk activities must be improved by addressing language barriers among workers. Assigning personnel to safety-critical roles should consider communication competency, supported by translators where necessary and the use of visual aids during pre-task briefings to enhance understanding [15][16].

Supervision should be strengthened through clear accountability and continuous presence during high-risk operations. Supervisors must enforce compliance with approved procedures, correct unsafe practices immediately and apply administrative action where responsibilities are no fulfilled to reinforce safety culture [5][17]. In addition, workers and signalmen should be empowered with clear stop-work authority when unsafe conditions are identified, supported by refresher training to promote proactive hazard communication and intervention [10].

6. Conclusion

This study evaluated the implementation of Hazard Identification, Risk Assessment and Risk Control (HIRARC) during tower crane lifting operations in a high-rise Industrialized Building System (IBS) construction project through a qualitative case study of a fall incident involving a signalman. The findings indicate that although

hazards, risk levels and control measures were formally documented in the Method Statement and Job Safety Analysis (JSA), their implementation at the site level was inconsistent.

The results highlight a significant gap between planned safety measures and actual work practices. Key contributing factors included non-compliance with approved work procedures, inadequate working platforms, ineffective communication during lifting operations and insufficient supervision. These weaknesses reduced the effectiveness of documented HIRARC measures and increased workers' exposure to fall-related hazards.

Overall, the study demonstrates that effective HIRARC implementation requires more than comprehensive documentation. It depends on practical application through active supervision, clear communication and continuous monitoring of site conditions. Strengthening these elements is essential to ensure that identified hazards and control measures are consistently enforced during high-risk lifting operations in high-rise IBS construction projects. The findings provide practical insights for improving safety management practices and reducing the likelihood of similar incidents in the future.

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Author Contribution

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