PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 7 No. 1 (2026) 852-861
https://publisher.uthm.edu.my/periodicals/index.php/peat

# Assessing Occupational Hazards for Pre-Construction Works at Construction Site

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DOI: https://doi.org/10.30880/peat.2026.07.01.096

**Article Info**

Received: 12 January 2026
Accepted: 20 February 2026
Available online: 25 May 2026

**Keywords**

Occupational hazards, Pre-construction works, Construction safety, HIRARC, Piling works, Risk assessment

**Abstract**

The construction industry is one of the high-risk work environments, especially during the pre-construction phase due to the various dynamic activities along with the presence of heavy equipment, excavation and piling works. Despite the already existing safety regulations, construction site accidents remain as a serious problem in early phases of construction. This study aims to assess occupational hazards associated with pre-construction works at a construction site. These early-stage operations often involve high levels of risk to workers' safety and health, especially when proper safety controls are not effectively implemented. The study applied the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach to systematically identify, evaluate, and manage workplace hazards. Data were collected through site observations (GEMBA walk), focused group discussions, and document analysis, including incident reports and company safety manuals. The findings identified fourteen hazards across seven pre-construction activities, with the highest risk levels associated with ground instability during piling rig setup and trench collapse during excavation works. Other frequently observed hazards included exposure to excessive noise and vibration during boring and hacking works, dust and silica inhalation, manual handling of heavy reinforcement bars, concrete splash, and heat stress during concrete pouring. The risk assessment results indicated that most hazards were classified as medium risk, while hazards related to excavation and piling rig stability were categorized as high risk due to their severe potential consequences. Control measures recommended included the installation of shoring and trench protection systems, use of steel outrigger mats for piling rigs, implementation of traffic management plans, wet cutting methods to control dust, provision of noise control measures, and enforcement of Permit-to-Work systems, supported by appropriate personal protective equipment. This study contributed to improved safety practices in the construction industry and serve as a useful reference for site management and future researchers.

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 852-861

## 1. Introduction

The construction industry is widely recognized as one of the most dangerous sectors in terms of workplace safety, where workers are frequently exposed to numerous risks and hazards. One of the most dangerous operations in the field of construction is pre-construction operation, which includes piling, excavation, pile cap construction, and slab laying [7]. These foundation works are marked by the utilization of heavy machines, deep excavations, high-pressure systems, and a significant amount of physical labor, resulting in very high occupational hazards despite advances in construction technology and regulations [1] [2] [3].

Construction sites continue to record a high rate of work-related accidents, particularly during pre-construction activities. Many incidents involve falls, machinery-related accidents, electrocution, trench collapses, and being struck by objects, with construction workers facing a much higher risk of fatal injury compared to other industries [4]. Excavation works expose workers to cave-ins, falls, and underground utility hazards, while piling works involve high-energy machinery that can lead to struck-by incidents, excessive noise, and vibration-related health effects. Pile cap and slab work further present risks such as musculoskeletal disorders, falls from height, and slipping hazards, which are often aggravated by poor site supervision, inadequate training, and insufficient use of protective systems [1].

In Malaysia, occupational safety in construction is regulated under the Occupational Safety and Health Act 1994, with enforcement carried out by the Department of Occupational Safety and Health. Employers are legally required to identify and control hazards, particularly in high-risk activities such as piling and excavation. Addressing safety issues during the pre-construction phase is not only a legal obligation but also essential for improving worker well-being, reducing project delays, and enhancing overall project performance. Systematic identification and assessment of occupational hazards during early construction stages are therefore necessary to strengthen prevention measures and promote a safety-first culture within the construction industry.

This study focuses on assessing occupational hazards associated with pre-construction activities, specifically piling, excavation, pile cap, and slab works, at a selected construction site in Malaysia. By applying the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methodology, the study aims to contribute to improved engineering safety practices, support compliance with occupational safety legislation, and promote safer working conditions for construction workers during the early and most critical phases of construction projects.

## 2. Methodology

The design for this case study will mainly be qualitative, although it may involve quantitative aspects if found to be required. This means that appropriate methods of data collections were purposefully chosen such as, observation, document analysis and survey methods. Data collection for this case study followed a methodical approach to ensure consistency and enhance the overall quality of the findings. Each method is strategically selected to collect rich, detailed data to enable a deep understanding of these occupational hazards due to pre-construction activities.

### 2.1 Data Collection Method

This study applied several data collection methods to obtain reliable information related to occupational hazards during pre-construction activities. The methods used included site observation, HIRARC, and focus group discussions. These approaches were selected to ensure that hazards, risks, and existing control measures could be accurately identified. The combination of these methods provided a comprehensive understanding of safety conditions at the construction site and supported effective risk assessment and analysis. A total of nine site personnel participated in this study. Participants were selected using non-probability purposive sampling, focusing on individuals who were directly involved in pre-construction activities such as piling, excavation, pile cap construction, and slab works. The selection criteria included: (i) active involvement in site operations, (ii) at least one year of working experience in construction projects, and (iii) willingness to share practical safety-related information during site observations and focused group discussions. This ensured that the information obtained reflected actual work practices and realistic hazard exposure during pre-construction works.

#### 2.1.1 Observation Method

Site observations were conducted over a period of four weeks during the active pre-construction phase of the project. Each observation session lasted approximately 1–2 hours, depending on the site activities being carried out. This duration allowed the researcher to observe routine work practices, changing site conditions, and recurring hazards associated with piling, excavation, and related activities. The observations were carried out using the GEMBA walk approach, which involved systematic walkthroughs of the construction site to observe actual work practices, unsafe acts, and unsafe conditions. A site inspection checklist was used to record hazards identified during activities such as mobilization and setup of piling rigs, boring operations, hacking of bore piles, excavation works, reinforcement installation, welding and cutting of rebar, and concrete pouring. GEMBA walks were conducted three to four times per week throughout the observation period, resulting in a total of 21 site walkthroughs. This repeated observation approach enabled the identification of both recurring and emerging hazards across different pre-construction areas.

### 2.1.2 HIRARC Method

HIRARC method was applied to systematically identify hazards, assess associated risks, and determine appropriate control measures. Hazards were evaluated based on their likelihood and severity using a risk matrix to determine risk levels for each identified activity. The use of HIRARC supports structured risk management and improves safety performance in high-risk construction activities [5].

### 2.1.3 Focus Group Discussion

Focus group discussions were conducted with site personnel to obtain practical insights into work processes, hazard exposure, and existing safety practices. These discussions complemented site observations by providing additional context on occupational hazards encountered during pre-construction works, thereby supporting more accurate hazard identification and risk assessment. In addition, inputs from participants were used to support the determination of likelihood and severity ratings for identified hazards based on their work experience and incident exposure. The discussions also contributed to the identification and refinement of appropriate risk control measures, ensuring that the proposed controls were practical and suitable for actual site conditions. To enhance the reliability of hazard scoring, the likelihood and severity ratings assigned to each identified hazard were not determined solely by the researcher. Instead, the risk ratings were reviewed and validated in consultation with a competent Safety and Health Officer (SHO) with practical experience in construction site safety management.

## 2.2 Data Analysis

Data analysis was conducted using HIRARC framework. Hazards identified during pre-construction activities were evaluated by estimating the likelihood of occurrence and the severity of consequences. Risk assessment involved examining the probability of a hazardous event, the extent of worker exposure, and the potential impact on safety and health. The risks were then ranked using a risk matrix to determine their level of significance, allowing critical hazards to be prioritized for control [6].

Based on the assessed risk levels, appropriate control measures were determined in accordance with the hierarchy of controls. This included elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment. The analysis considered existing safety measures and identified the need for additional controls to ensure that significant hazards were adequately managed. This structured approach supports improved safety performance in high-risk construction activities and ensures systematic management of occupational hazards during pre-construction works [6].

# 3. Results and Discussion

This section presents the results obtained from the HIRARC analysis conducted on pre-construction activities. The aim was to systematically identify occupational hazards, assess associated risk levels, and evaluate existing control measures. Observations were based on site visits, document reviews, and GEMBA walks, representing practical industry-based scenarios. Pre-construction works expose workers to various physical, environmental, and operational hazards. Based on their risk rating, the results are categorized into many relative risk values, which are displayed in the HIRARC table in Tables 1, 2, and 3 below. Out of all seven activities, fourteen hazards have been identified.

**Table 1** *Hazard Identification*

| No | Work Activity | Hazard | Risk Consequences | Existing Control |
|---|---|---|---|---|
| 1 | Mobilization & Setup of Piling Rig | Large machinery movement (crane, rig, lorry) | Struck, crushed, or trapped by moving vehicle | Trained operator, signalman, whistle |
| | | Ground instability at rig outrigger location | Rig overturn leading to crushing injuries or fatality | Ground inspection prior to setup |
| 2 | Boring Operation (Pile Drilling) | Exposure to excessive noise | Hearing loss | Basic awareness training, earplugs |
| | | Falling into open bore hole | Severe injury, spinal trauma, or fatality | Temporary barricades around open bores |

**Table 1 (continued)** *Hazard Identification*

| No | Work Activity | Hazard | Risk Consequences | Existing Control |
|---|---|---|---|---|
| 3 | Hacking Bore Pile | Flying concrete fragments | Eye injury, laceration, or penetrating injuries | Safety goggles, gloves |
| | | Hand–arm vibration from jackhammer/breaker | HAVS, muscle fatigue | Basic PPE (helmet, shoe, gloves) |
| | | Dust and silica inhalation | Chronic respiratory disease (silicosis) | Basic face mask |
| | | Exposure to excessive noise | Hearing loss | Basic awareness training, earplugs |
| 4 | Excavation | Cave-in / trench collapse | Crush injury or burial (fatal) | Sloping, slope protection (canvas) |
| | | Worker falling into excavation pit | Severe injury, spinal trauma, or fatality | Temporary barricades around excavation pit |
| 5 | Reinforcement Installation (Pile Cap) | Manual handling of heavy rebar | Back strain, musculoskeletal disorders | Manual handling training, gloves |
| 6 | Welding and Cutting Rebar | Heat and sparks (metal spatter or sparks) | Burns to the skin and eyes, ignition of nearby combustible materials | Gloves and welding shield |
| 7 | Concrete Pouring (Pile Cap / Slab) | Concrete splash | Chemical burns to skin and severe eye irritation | Gloves and goggles |
| | | Prolonged exposure to high temperatures | Heat stroke, fatigue, heat exhaustion | Provision of water supply and rest area |

**Table 2** *Risk Assessment*

| No | Work Activity | Hazard | Likelihood | Severity | Risk Rating | Risk Level |
|---|---|---|---|---|---|---|
| 4 | Excavation | Cave-in / trench collapse | 3 | 5 | 15 | High |
| | | Worker falling into excavation pit | 3 | 4 | 12 | Medium |
| 5 | Reinforcement Installation (Pile Cap) | Manual handling of heavy rebar | 3 | 3 | 9 | Medium |
| 6 | Welding and Cutting Rebar | Heat and sparks (metal spatter or sparks) | 3 | 3 | 9 | Medium |
| 7 | Concrete Pouring (Pile Cap / Slab) | Concrete splash | 2 | 3 | 6 | Medium |
| | | Prolonged exposure to high temperatures | 3 | 3 | 9 | Medium |
| No | Work Activity | Hazard | Likelihood | Severity | Risk Rating | Risk Level |
| 1 | Mobilization & Setup of Piling Rig | Large machinery movement (crane, rig, lorry) | 3 | 4 | 12 | Medium |
| | | Ground instability at rig outrigger location | 3 | 5 | 15 | High |
| 2 | Boring Operation (Pile Drilling) | Exposure to excessive noise | 3 | 3 | 9 | Medium |
| | | Falling into open bore hole | 2 | 5 | 10 | Medium |
| 3 | Hacking Bore Pile | Flying concrete fragments | 3 | 3 | 9 | Medium |
| | | Hand–arm vibration from jackhammer/breaker | 3 | 3 | 9 | Medium |
| | | Dust and silica inhalation | 3 | 3 | 9 | Medium |
| | | Exposure to excessive noise | 3 | 3 | 9 | Medium |

**Table 2 (continued)** *Risk Assessment*

**Table 3** *Risk Control*

| No | Work Activity | Hazard | Recommended Control Measure |
|---|---|---|---|
| 1 | Mobilization & Setup of Piling Rig | Large machinery movement (crane, rig, lorry) | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Install temporary barriers, physical segregation of plant and pedestrian routes<br>**Admin Control:** Strict traffic management plan (TMP)<br>**PPE:** High-visibility clothes and steel-toe footwear |
| | | Ground instability at rig outrigger location | **Elimination:** N/A<br>**Substitution:** N/A |

| | | | |
|---|---|---|---|
| | | | **Engineering Control:** Install steel outrigger mats/plates<br>**Admin Control:** Daily pre-shift ground condition checks and logbook<br>**PPE:** N/A |
| 2 | Boring Operation (Pile Drilling | Exposure to excessive noise | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Use acoustic enclosures<br>**Admin Control:** Conduct noise risk assessment, limit exposure times, implement job rotation<br>**PPE:** SIRIM approved earmuffs |
| | | Falling into open bore hole | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Install robust perimeter guardrails with netting and toe boards **Admin Control:** Supervisor conducting daily inspection confirming covers in place<br>**PPE:** High visibility clothing |

**Table 3 (continued)** *Risk Control*

| No | Work Activity | Hazard | Recommended Control Measure |
|---|---|---|---|
| 3 | Hacking Bore Pile | Flying concrete fragments | **Elimination:** N/A<br>**Substitution:** Use mechanical cutters that minimize<br>**Engineering Control:** N/A<br>**Admin Control:** Establish exclusion zones, ensure only trained work carry out work **PPE:** Full face shield, safety helmet with face shield, cut-resistant clothing |
| | | Hand–arm vibration from jackhammer/breaker | **Elimination:** N/A<br>**Substitution:** Use hydraulic or pneumatic breakers<br>**Engineering Control:** N/A<br>**Admin Control:** Implement exposure time limits, job rotation, training on tool handling **PPE:** Certified anti-vibration gloves and insulated tool handles |
| | | Dust and silica inhalation | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Use wet cutting methods, portable ventilation fan<br>**Admin Control:** Training on respiratory hazards<br>**PPE:** Provide certified N95 or P3 respirators |
| | | Exposure to excessive noise | **Elimination:** N/A<br>**Substitution:** N/A |

| | | | |
|---|---|---|---|
| | | | **Engineering Control:** Use acoustic enclosures<br>**Admin Control:** Conduct noise risk assessment, limit exposure times, implement job rotation<br>**PPE:** SIRIM approved earmuffs |
| 4 | Excavation | Cave-in / trench collapse | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Install shoring or shielding systems<br>**Admin Control:** Daily inspection of trench and soil conditions, Brief workers on trench collapse symptoms<br>**PPE:** Safety boots, safety helmet, reflective vest |
| | | Worker falling into excavation pit | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Provide edge protection, Barricade the excavate area surroundings<br>**Admin Control:** Use Permit-to-Work system, Place warning signage at edges<br>**PPE:** Safety boots, safety helmet, reflective vest |

**Table 3 (continued)** *Risk Control*

| No | Work Activity | Hazard | Recommended Control Measure |
|---|---|---|---|
| 5 | Reinforcement Installation (Pile Cap) | Manual handling of heavy rebar | **Elimination:** Use pre-fabricate rebar<br>**Substitution:** N/A<br>**Engineering Control:** Use mechanical aids like chain blocks or cranes<br>**Admin Control:** Implement safe lifting training and ergonomic awareness, Use buddy system<br>**PPE:** Back support belt, safety boots, safety helmet |
| 6 | Welding and Cutting Rebar | Heat and sparks (metal spatter or sparks) | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Provide welding curtains or non-combustible barriers<br>**Admin Control:** Implement a Hot Work Permit, Trainings on safe welding practices and fire prevention<br>**PPE:** Welding helmets with the correct shade rating for eye/face protection, flame-resistant welding glove |
| 7 | Concrete Pouring (Pile Cap / Slab) | Concrete splash | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Designated wash stations with emergency eyewash<br>**Admin Control:** Pre-task briefing, spill response procedures<br>**PPE:** Chemical-resistant gloves, full-face shields, rubber boots |
| | | Prolonged exposure to high temperatures | **Elimination:** N/A<br>**Substitution:** N/A<br>**Engineering Control:** Provide shaded work areas, evaporative cooling stations<br>**Admin Control:** Implement WBGT monitoring, job rotation<br>**PPE:** Lightweight PPE, cooling vests |

The findings indicate that pre-construction activities involve multiple high-risk tasks that expose workers to a wide range of occupational hazards. Hazards identified during piling, boring, hacking bore piles, excavation, reinforcement installation, welding, and concrete pouring include physical hazards such as heavy machinery movement, ground instability, flying concrete fragments, excessive noise, vibration, and falling into open pits. Environmental and health-related hazards such as dust and silica inhalation, heat stress, and chemical exposure from wet concrete were also commonly observed. These hazards are inherent to pre-construction works due to the dynamic nature of activities, confined working spaces, and extensive use of heavy equipment. The identification process highlights that many hazards occur repeatedly across different work activities, indicating systemic safety challenges rather than isolated incidents.

Risk assessment results reveal that most identified hazards fall within the medium-risk category, while a smaller number are classified as high risk. Medium-risk hazards are mainly associated with prolonged exposure, such as continuous noise during boring operations, dust and silica inhalation during hacking works, hand-arm vibration from power tools, and heat stress during concrete pouring. Although these hazards may not cause immediate severe injuries, long-term exposure can result in occupational illnesses such as hearing loss, silicosis, musculoskeletal disorders, and heat-related illnesses. High-risk hazards were primarily related to ground instability and excavation works, including trench collapse and instability at piling rig outriggers. These hazards carry severe consequences such as fatalities, serious injuries, and major equipment damage. Their classification as high risk reflects the combination of moderate likelihood and catastrophic severity, emphasizing the need for immediate and effective control measures.

The recommended control measures were developed based on the hierarchy of controls, with particular focus on high-risk pre-construction activities, mainly piling rig setup and excavation works, which were identified as having the most severe potential consequences. For hazards related to ground instability at piling rig outriggers, engineering controls such as the use of steel outrigger mats and ground reinforcement were prioritized to prevent equipment overturning and crushing incidents. Similarly, for excavation-related hazards, including trench collapse and falls into excavation pits, the implementation of trench shoring systems, edge protection, and physical barricades was emphasized as primary risk reduction strategies.

Administrative controls, including Permit-to-Work systems, daily inspection of ground and trench conditions, worker training, job rotation, and exposure time limits, were proposed to strengthen supervision and ensure compliance with safe work procedures for these high-risk activities. Personal Protective Equipment, such as helmets, face shields, respirators, ear protection, gloves, and safety boots, was recommended as supplementary protection against residual risks that could not be fully eliminated through engineering and administrative controls. Overall, the findings indicate that while existing control measures contribute to risk reduction, enhanced engineering controls and stricter on-site supervision for excavation and piling operations are critical to further minimize occupational hazards during pre-construction works. The application of the HIRARC framework enables systematic prioritization of these high-risk activities and supports more targeted decision-making in construction safety management.

## 4. Conclusion

This study concluded that pre-construction activities, particularly piling, excavation, pile cap construction, and slab works, expose workers to significant occupational hazards that pose serious risks to safety and health at construction sites. Through the application of the Hazard Identification, Risk Assessment, and Risk Control methodology, various physical, environmental, and operational hazards were systematically identified across different work activities. The findings confirm that pre-construction works are inherently high-risk due to the involvement of heavy machinery, ground instability, confined working areas, and labour-intensive operations.

The risk assessment results indicate that most hazards fall within the medium-risk category, mainly associated with prolonged exposure to noise, vibration, dust, manual handling, and heat stress. However, several hazards were classified as high risk, particularly those related to excavation works and piling operations, such as trench collapse and ground instability. These hazards present severe consequences including serious injury and fatality, highlighting the critical need for effective risk management during the early stages of construction. The study demonstrates that although existing control measures are in place, gaps remain in fully mitigating these risks, especially where engineering controls and supervision are insufficient.

In conclusion, the application of the HIRARC framework proved to be an effective and practical approach for assessing occupational hazards in pre-construction works. The findings emphasize the importance of systematic hazard identification, accurate risk evaluation, and the implementation of appropriate control measures to improve occupational safety and health performance. This study contributes valuable insights for construction practitioners in strengthening safety management practices and reducing workplace accidents during pre-construction phases.

## Acknowledgement

The author would like to express gratitude towards the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, for its support.

## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

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