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Development of Hazard Identification, Risk Assessment, and Opportunities (HIRAO) Report in ISO 45001:2018 for Segmental Box Girder (SBG) Installation in the KVLRT3 Project

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Abstract: The construction sector is associated with various accidents and fatal injuries. In the KVLRT3 project, various works have high potential of risk related injuries and ill health including the job sequence for SBG installation at GS10 workplace. In this study, the Hazard Identification, Risk Assessment, and Opportunities (HIRAO) report was developed to analyze the hazards involved in the job sequences of SBG installation by the balanced cantilever method using a crane. The HIRAO report is produced by identifying the hazards involved in the activities using all the source information such as workplace inspection, injuries, illness, incident, accident report, team consultation, and employee feedback and observation. The risk associated was identified and analyzed by qualitative method to observe the level of the risk-based on previous actual accidents that happened in the construction industry. The opportunities for every hazard involved in the job sequences also were identified to complete the HIRAO report as one of the elements of ISO 45001:2018 based on the SWOT analysis constructed. From the current risk assessment, the additional risk control was measured for the future project to reduce the risk at once it will give opportunities to prevent or minimize accidents at the workplace. The HIRAO report produced will be proposed to the company AlKauthar Kinematics as a part of the element in ISO 45001:2018. However, the ISO 45001:2018 cannot be implemented yet due to the budget issues.

Keywords: Construction, HIRAO Report, Risk Assessment, SWOT Analysis

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1. Introduction

The construction industry is the most important sector that led to the country's economic growth. It is expected to grow in real terms between 2022-2025 after had slowed in 2019 due to pandemic Coronavirus Disease 19 (Covid-19). The construction site is well known as the most dangerous working environment that can cause injuries and ill health not only to the employees but also to the people nearby the construction site. Companies of all sizes and industries are now seeking management systems to improve their health and safety performance as health and safety legislation and responsibilities become more prevalent.

Despite huge improvements in occupational health and safety (OHS), that have developed in practices intended to prevent injuries and diseases in the workplace, many organizations encounter problems [1]. The development of international standards such as ISO 9001:2015, Quality Management System (QMS), ISO 14001:2015, Environmental Management System (EMS), and ISO 45001:2018, Occupational Health and Safety Management System (OHSMS) is one of the solutions to minimize the injuries and ill health at the workplace. Work-related accidents and illnesses are occurrences that may and must be prevented through planning, management, and evaluation of the implementation of the control measures in place [2].

The construction site of Klang Valley Light Rail Transit Line 3 (KVLRT3) involves the sequence of installation Segmental Box Girder (SBG) has various works that have high potential and risk of injuries and ill health. The hazards must be identified for every step in the sequence of the installation of SBG.

OHSMS, ISO45001:2018 was proposed in this research for work related to the installation of SBG to ensure the safety at the workplace and the improvement of the OHSMS of the company at once giving trust to the organizations.

2. Segmental Box Girder (SBG)

In the last few decades, precast concrete segmental bridge construction has been increasingly famous all over the world. A Segmental Box Girder (SBG) is composed of small parts defined as segments. These girders are widely used for railway bridges, footbridges, and highway bridges. SBG has numerous benefits, including efficient installation, low life-cycle costs, excellent quality management, and reduced environmental impact [3]. These advantages can be accomplished by employing local labor and materials, improving quality control, and requiring minimal additional maintenance. They also have unique benefits such as durability, fire resistance, deformation control, rider ease of maintenance, damage tolerance, and other redundancies [4]. In both urban and rural settings, these bridges can handle highways, railways, and rapid transportation. They can be straight or curved, and they can cover large distances across tough obstacles and terrain.

SBG consists of several methods of construction such as the Balanced Cantilever Method or Free Cantilever Method, Incremental Launching, and Span-by-Span Construction [5]. The segments may either be cast-in-situ or precast/prefabricated. The method of construction is a combination of processes and construction operations that have been established and evaluated by industry standards [6]. The innovation development approach speeds up the construction process, allowing development operations to go as planned while still being cost-effective. The determination of construction methodologies is very important when working on SBG. It is not only construction loads that will affect the design in fact construction methodologies also affected the design. For example, the tendon layouts. The selection of construction methodologies must be suitable and convenient to the project environment conditions that considered every aspect. The method used by AlKauthar Kinematics Sdn. Bhd. for the SBG installation is the Balanced Cantilever Method using a crane.

A. Balanced Cantilever Method

In the design of SBG, the balanced cantilever method is viewed as the most reasonable and logical approach. Precast and cast-in-situ segmental bridges both benefit from balanced cantilever construction. The advantage of this method is the elimination of conventional falsework and temporary support [7]. When scaffolding is difficult or even impossible to build over large valleys, huge rivers, or costly base requirements for scaffolds, this method is highly suggested [8].

Bridges are constructed from one or more piers using formwork carriers in this approach. Through concreting, a critical segment, and post-tensioning tendons, each cantilevered part of the superstructure is linked to the previous one.

Figure 1 shows how to construct a box girder with a traveler that uses the balancing cantilever method. A short cross-section slab containing counterweights on one side is cast into the workpiece that is supported from the ground of each column to assist cantilevering [9]. To achieve stability, a temporary connection is established to balance the other side. Secure counterweight adjustment during each cantilever implementation stage [9].

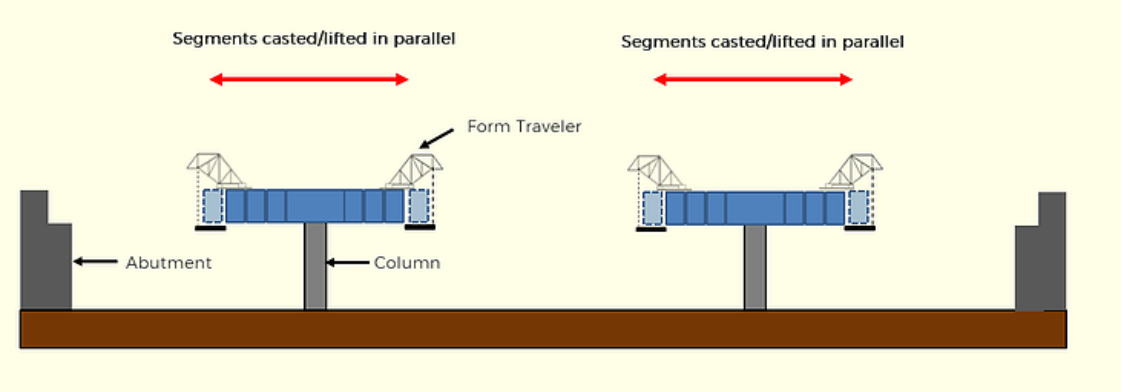


Figure 1: Balanced Cantilever Method using a traveler

2.1 Occupational Health and Safety Management System (OHSMS), ISO 45001:2018

The ISO 45001:2018 "Occupational health and safety management systems – Requirements with guidance for use" standard is designed to assist all firms in their efforts to create healthy and safe workplaces, preserve employee well-being, and eliminate work-related injuries and incidents.

The new standard differs significantly from BS OHSAS 18001 in that it considers aspects of leadership and employee engagement in OHS, as well as being associated with European legislation such as the OHS Framework Directive 89/391/EEC [10]. The standard follows the same management proposed system as the International Labor Organization (ILO) guidelines for OHS systems, and it meets the requirements outlined by the ILO. Unlike most national OHS regulations, which make the implementation of OHS policies mandatory, ISO 45001 is optional; it is applied after management decides to run all elements of OHS in a systematic and standardized manner, and it can be established by any organization looking to develop, maintain, and strengthen an OHSMS and have a platform that ensures compliance from its safety policy and the appropriate binding legislation.

2.2 Hazard Identification, Risk Assessment, and Opportunities (HIRAO)

HIRAO process is in clause 6.1 of ISO 45001:2018 which is action to address risks and opportunities.

A. Hazard Identification

A workplace hazard is something that has the potential to harm employees or others who are near the workplace. Regardless of whether you work in a construction area or otherwise, there must be risks

in every profession and environment. It is the responsibility of everyone in the workplace, including managers, employers, and employees, to identify and control risks [11].

Hazard identification is an element in the process of determining if an event, object, or set of stuff has the potential to cause harm [12]. It is a process of classifying, listing, and finding hazards involves in the workplace. Hazards can be identified using a variety of approaches, including going around the workplace, asking your reps, and checking the company's information sheet or accident records. Figures 2 and 3 depict the consequences of late hazard identification and early hazard identification, respectively [13].

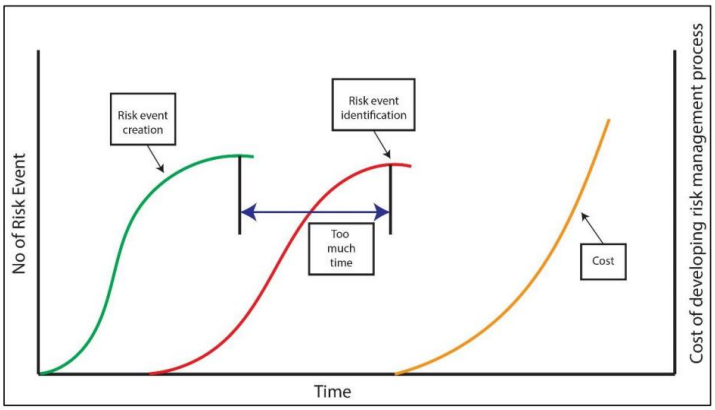


Figure 2: Late hazard identification

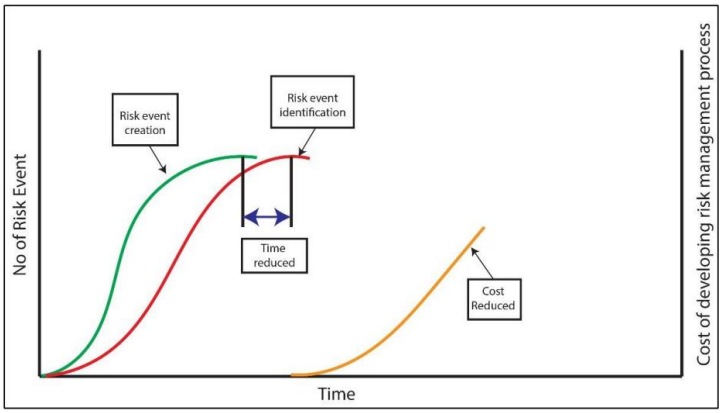


Figure 3: Early hazard identification

B. Risk Assessment

Risk assessment and management are also essential components of an engineer's profession. All hazards or possible risks must be identified, and the probabilities and effects of each must be assessed. The risk must be assessed to determine if it is acceptable or unacceptable. If the risk is manageable, risk management actions should be carried out; if the risk is intolerable, no activities should be carried out [13]. To enhance the efficacy of the implemented strategy or action, regular assessment and monitoring are essential.

C. Opportunities

The ISO 45001:2018 clause 6.1.2.3 encourages us to identify OHS and other opportunities for the OHS management system. Occupational health and safety opportunities are those that are directly tied to improving our OHS performance, such as changing the way we operate to avoid harm or reducing workplace risks [14].

3. Research Method

3.1 Qualitative Assessment

Dependent on the type and hazards of the business, the standard enables the company to determine the most appropriate monitoring and reporting. Methods used in analyzing risks can be qualitative, semi-quantitative, or quantitative. For this research, the qualitative assessment will be used to measure the risk.

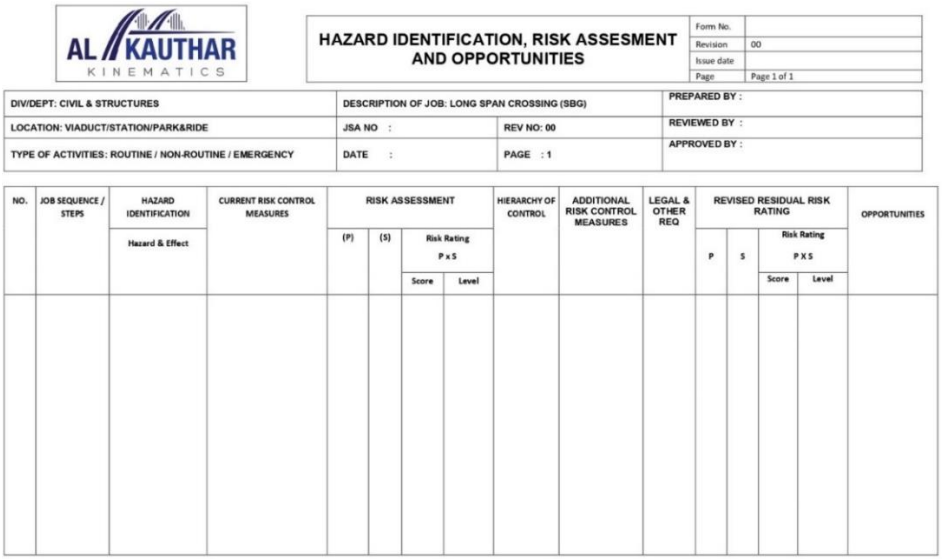
In a qualitative approach, words are used to express the extent of prospective severity as well as the likelihood of that severity occurring. Various explanations for different dangers might be applied, and these ratings can be changed or modified to accommodate the situation. To estimate the likelihood and severity classification, this method relies on expert knowledge and experience [15]. This method applied the risk formula which is considering the likelihood and severity and the risk rating recognized as a high risk, medium risk, or low risk.

3.2 SWOT analysis

SWOT analysis has been used since the 1960s and has been commended for its practicality [16]. The analysis is the most widely used tool for determining and positioning an organization's resources and environment in four regions which are strength, weakness, opportunities, and threats. Strengths and Weaknesses are internal elements that can be controlled which motivate or hinder organizations accomplish their goals while Opportunities and Threats are external factors which is uncontrollable that enable or prevent organizations from achieving their goals. The elements in these four domains can be used to identify the organization's key abilities and knowledge for decision-making, planning, and strategy-building [17].

3.3 HIRAO report

The new ISO 45001:2018 standard introduced a new definition of risk, stating that the unpredictability of activity might result in both negative and positive deviations from an intended outcome. Negative deviations will call as risks while opportunities are positive deviations. In terms of negative deviations, the planning phase's preventative approach, which includes hazard identification, risk assessment, and the implementation of essential control mechanisms, stays the same. Figure 4 below shows the HIRAO form that will be used by AKK for producing the HIRAO report in the implementation of ISO 45001:2018.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HAZARD IDENTIFICATION, RISK ASSESMENT AND OPPORTUNITIES

Form No.	
Revision	00
Issue date	
Page	Page 1 of 1

DIV/DEPT: CIVIL & STRUCTURES	DESCRIPTION OF JOB: LONG SPAN CROSSING (SBG)	PREPARED BY :
LOCATION: VIADUCT/STATION/PARK&RIDE	JSA NO : REV NO: 00	REVIEWED BY :
TYPE OF ACTIVITIES: ROUTINE / NON-ROUTINE / EMERGENCY	DATE : PAGE : 1	APPROVED BY :

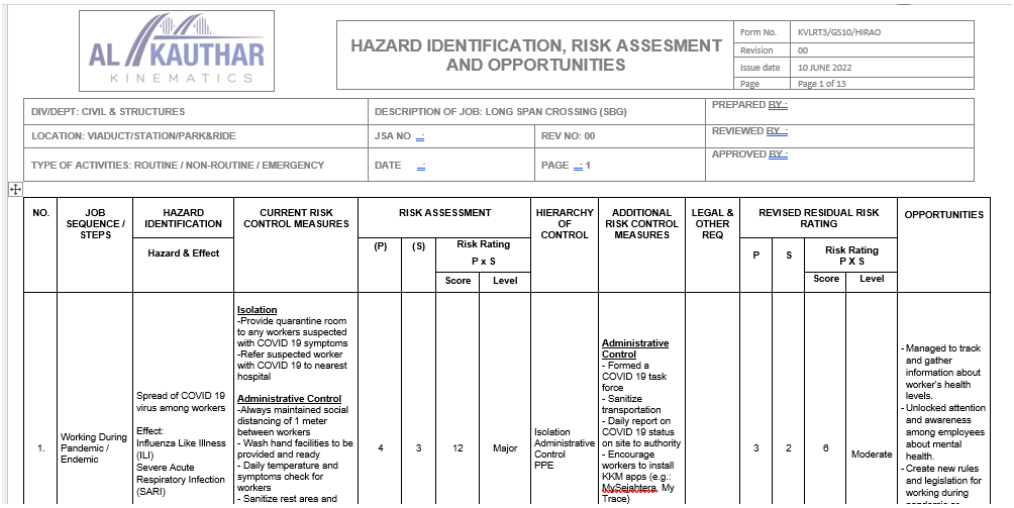
NO.	JOB SEQUENCE / STEPS	HAZARD IDENTIFICATION	CURRENT RISK CONTROL MEASURES	RISK ASSESSMENT				HIERARCHY OF CONTROL	ADDITIONAL RISK CONTROL MEASURES	LEGAL & OTHER REQ	REVISED RESIDUAL RISK RATING				OPPORTUNITIES
		Hazard & Effect		(P)	(S)	Risk Rating P x S					P	S	Risk Rating P X S		
						Score	Level						Score	Level	

Figure 4: HIRAO form

4. Results and Discussion

4.1 HIRAO report

The HIRAO report as shown in Figure 5 proposed in this study consist of six elements including job sequence, hazard identification, current risk control measures, risk assessment, additional risk control measures, revised residual risk rating, and opportunities.



AL KAUTHAR KINEMATICS

HAZARD IDENTIFICATION, RISK ASSESMENT AND OPPORTUNITIES

Form No.	KVLRT3/GS10/HIRAO
Revision	00
Issue date	10 JUNE 2022
Page	Page 1 of 13

DIV/DEPT: CIVIL & STRUCTURES	DESCRIPTION OF JOB: LONG SPAN CROSSING (SBG)	PREPARED BY: -
LOCATION: VIADUCT/STATION/PARK&RIDE	JSA NO: - / REV NO: 00	REVIEWED BY: -
TYPE OF ACTIVITIES: ROUTINE / NON-ROUTINE / EMERGENCY	DATE: - / PAGE: 1	APPROVED BY: -

NO.	JOB SEQUENCE / STEPS	HAZARD IDENTIFICATION	CURRENT RISK CONTROL MEASURES	RISK ASSESSMENT (P)	(S)	Risk Rating P x S Score	Level	HIERARCHY OF CONTROL	ADDITIONAL RISK CONTROL MEASURES	LEGAL & OTHER REQ	REVISED RESIDUAL RISK RATING P	S	Risk Rating P X S Score	Level	OPPORTUNITIES
		Hazard & Effect													
1.	Working During Pandemic / Endemic	Spread of COVID 19 virus among workers Effect: Influenza Like Illness (ILI) Severe Acute Respiratory Infection (SARI)	**Isolation** -Provide quarantine room to any workers suspected with COVID 19 symptoms -Refer suspected worker with COVID 19 to nearest hospital **Administrative Control** -Always maintained social distancing of 1 meter between workers - Wash hand facilities to be provided and ready - Daily temperature and symptoms check for workers - Sanitize rest area and	4	3	12	Major	Isolation Administrative Control PPE	**Administrative Control** - Formed a COVID 19 task force - Sanitize transportation - Daily report on COVID 19 status on site to authority - Encourage workers to install KKM apps (e.g.: MySejahtera, My Trace)		3	2	6	Moderate	- Managed to track and gather information about worker's health levels. - Unlocked attention and awareness among employees about mental health. - Create new rules and legislation for working during

Figure 5: HIRAO report

4.2 Hazard Identification

The hazards were identified based on accidents that may be happened according to the job sequences and also from the accidents that frequently happened in the past according to the same activities applied in SBG installation activities.

The hazards involved in the activities of SBG installation in the KVLRT3 project at GS10 workplace are the spread of Covid-19 virus among workers, mobilization of types of machinery, working above live traffic, outrigger placed on soft ground or uneven platform, mechanical malfunction, fingers being caught in between, working at height, lifting gear foul during lifting, adverse weather, unexpected movement of cargo or load during lifting due to wind, miscommunication between signalman and crane operator, hit by moving or slewing object, entangled between lifting lugs, awkward posture, and exposure to moving vehicles or objects.

4.3 Risk Assessment

There are two sections of risk assessment which are risk assessment for current risk control that has been implemented at the GS10 workplace and risk assessment for additional risk control that can be implemented for the future project. This risk assessment will be explained in the next sections by considering several hazards mentioned in the HIRAO report.

The range of risk rating will be considered insignificant if the risk rating is 1, minor from 2 until 4, moderate from 5 until 9, major from 10 until 19, and critical from 20 until 25 (refer to Table 1).

Table 1: Risk rating determination

		PROBABILITY (P)				
		5	4	3	2	1
SEVERITY (S)	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3

2	10	8	6	4	2
1	5	4	3	2	1

1	Significant
2-4	Minor
5-9	Moderate
10-19	Major
20-25	Critical

4.4 Risk Control

For the current risk control, the third column of the HIRAO report shows that the most control measures used are administrative control and engineering control as the job sequences involving many equipment and expertise.

The administrative control was used for every hazard involved in this SBG installation activities. Administrative controls typically change the behavior of people rather than removing the actual hazard or providing personal protective equipment. The thing that keeps on repeating in the risk control for administrative control means that those issues are the most important that should be controlled which is permitted. There is a lot of equipment and expertise involved in the construction industry, that is why a permit is important to ensure the rules and legislation were followed.

The additional risk control was measured in this study as one of the elements in the HIRAO report. Additional risk control is not an essential part of the common report. This part was added for the improvement of risk control for the future or next project to reduce and minimize the number of accidents that may be happened at the workplace. Also, the risk rating can be compared between current risk control and additional risk control to observe whether the additional risk control will give the effect to risk rating or not.

4.5 Comparison of risk rating between current risk control and after additional risk control was added

The graph shown in Figure 6 was plotted by considering 3 hazards which are the spread of the Covid 19 virus among workers, unexpected movement of cargo or load during lifting due to wind, and awkward posture. All the risk ratings for the hazards mentioned decreased after the revision of risk control was made.

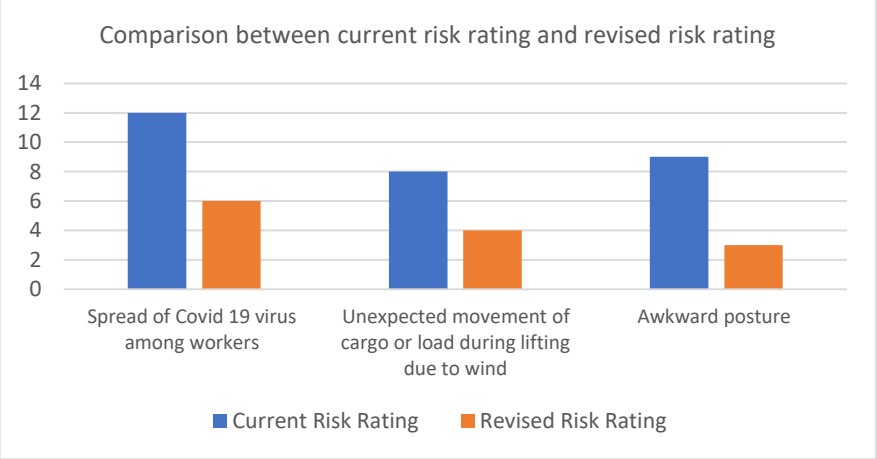


Figure 6: Comparison between current risk ratings

4.6 Opportunities

The opportunities were recognized by constructed SWOT analysis as shown in Table 2. The SWOT analysis constructed in Table 2 was based on several hazards that came from the job sequences of SBG installation mentioned in the HIRAO report. The focus of this analysis was on opportunities as it is one of the required elements to complete the HIRAO report.

Table 2: SWOT analysis

Strengths	Weaknesses
S1: The existence of Covid-19 SOP by the company. S2: Having competent workers and a good Transport Management Plan (TMP). S3: Used different types of cranes according to the environment. S4: Having good project planning by considering the adverse weather.	W1: Most of the job sequences involve close distancing among workers. W2: High risk of job sequence that involves road users. W3: Taking time to find a good condition of ground to place the crane's outrigger. W4: Unpredict weather can cause project delays.
Opportunities	**Threats**
O1: Managed to track and gather information about workers' health levels and unlocked attention and awareness among employees about mental health. O2: High potential in creating network collaboration with KESAS. O3: Ensure all lifting activities are by regulations and add knowledge and expertise to workers on different types of cranes, loads, and soil tests. O4: Using advances and modern equipment for a weather forecast.	T1: Project delay if there is a Movement Control Order (MCO). T2: Complicated guidelines or requirements by KESAS. T3: Using costly crane due to limited workspace. T4: Project delay caused by unavoidable season.

5. Conclusion

The HIRAO report has been successfully constructed and achieved all the objectives. the hazards and risks associated with the job sequences of SBG installation for the GS10 workplace were determined. The hazards and risks listed in the HIRAO report were based on existing hazards that were already mentioned before in the previous report for Job Safety Analysis (JSA) for the KVLRT3 project which is the HIRADC report. The opportunities constructed using SWOT analysis can be recognized by the company by implementing all the risk control mentioned in the HIRAO report. Therefore, it can be concluded that the HIRAO report was successfully proposed to the company, AKK. However, the process for adopting ISO 45001:2018 for the company, AKK was not run yet due to the unavailable awarded project for construction in the rail industry and the cost of adopting ISO 45001:2018. The HIRAO report still can be used for the next project and is ready to be included in ISO 45001:2018 once the company decided to process it.

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