FINAL PROJECT

APPLICATION OF CONSTRUCTION SAFETY ANALYSIS (CSA) METHOD TO ASSESS OCCUPATIONAL RISK IN LIFTING AND TRANSPORTING ACTIVITIES USING FREESTANDING TOWER CRANE

A Thesis Presented to the Universitas Islam Indonesia Yogyakarta as Partial Fulfillment of the Requirements to Obtain the Bachelor Degree in Civil Engineering Department

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PLAGIARISM FREE STATEMENT

I declare truthfully that the Final Project Report entitled "Application of Construction Safety Analysis (CSA) Method to Access Occupational Risk in Lifting and Transporting Activities Using Freestanding Tower Crane" that I have composed as partial fulfilment the bachelor program in Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia is my own work. As for certain passages in the writing of Final Project Report that I quoted from the work of others have been included in the sources clearly according to the norms, rules, and ethics of writing scientific paper. If in the future all or part of this Final Project Report was not by my own making or there is plagiarism in certain parts, I am willing to accept the sanctions, including the revocation of my academic title, according to the applicable regulations of the laws.

Yogyakarta, September 15th 2023

Who make the statement,

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ABSTRACT

These days, the construction of high-rise buildings continues to be carried out massively which in the process of construction involves a lot of heavy equipment, especially crane. Crane is one of the essentials machineries in the construction of high-rise buildings because it plays a prominent role due to importance in lifting and transporting material. There are many types of cranes that can be used according to conditions in the field, one of them is tower crane. There are many consequences that will occur in tower crane activities. Minor to death and property damage are the consequences of tower crane work accidents. Therefore, this research conduct to identify potential hazards in lifting and transporting activities using freestanding tower crane and determine actions to be taken to control potential hazard.

This research using the Construction Safety Analysis (CSA) method to assess occupational risk in tower crane activities. Each sequence of tower crane work from installation of tower crane, operation of tower crane, and demolition of tower crane.

The results of this research show that there are 28 types of hazards that can occur in the tower crane workplace. From 28 types of hazards can be classified into 4 types of accidents: Technician and workers loss concentration, slipped, and fall from heights; technician and worker trapped, struck down, and grazed; equipment fell down and damaged; and materials are fell down, broken, or spilled. The hazard control that can be carried out are the substitution method, engineering control, administration, and using PPE.

Keywords: Tower Crane, High-rise building, Construction Safety Analysis Method

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The Final Project Report is not free of limitations. Hopefully this Final Project Report could give many benefits for the other researchers and readers especially in Civil Engineering Program.

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DEDICATION

The author would like to thank those who have helped author during the lecture period to the process of preparing this Final Project Report, the deepest gratitude to:

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CHAPTER I
INTRODUCTION

1.1 Background of the Study

Recently, infrastructure development is increasingly being carried out by both the government and private company. This development activity certainly has a positive impact on various sectors such as improving the economic sector, education, tourism, and other sectors in Indonesia. One of the infrastructures that are being intensively built is a multi-story building that will be used for offices, apartments, hotels, entertainment venues, restaurants, and education.

In the implementation of the construction of high-rise buildings, the risk of work-related accidents also increases. This could be due to a worker's lack of concentration, dangerous conditions and behaviour, lack of occupational safety signs, lack of safety knowledge, or lack of personal protective equipment. The problem is compounded by the development area that is not sterile from the activities of the public and the involvement of heavy equipment. The most used heavy equipment for lifting and transporting in the construction of high-rise buildings is a crane.

The utilization of cranes within the development industry around the world is exceptionally common. The differences in the utilization of cranes at development destinations incorporate the development of little, medium, and large-scale ventures. The employment of cranes in all sorts of development has expanded the efficiency rate of development ventures around the world.

Rapid construction is influenced by the selection of appropriate cranes and ongoing construction projects. The types of cranes needed to depend on the situation. For example, concrete works such as beams, columns, and walls on the second floor of an office building only required a crane to move, however, to work on a multi-story building of reinforced concrete, it is necessary to implement a tower crane. Basic types of cranes are divided into several categories such as

tower, mobile, hydraulic, overhead and gantry cranes. Based on these categories, the actual name of each crane can be identified (Hamid et al., 2019).

Tower cranes are the lifeblood of the construction industry, but tower crane accidents are still common. Although tower crane safety research has made great strides, systems thinking-based approaches are lacking. For example: On Wednesday, October 31 2018 three workers fell and died in a tower crane hotel project in Semarang, Indonesia. Tower crane accidents not only threaten the safety of workers, but also directly damage machinery, equipment, and buildings.

Based on Employee Social Security System data, in 2019 there were 114,000 work accident cases in Indonesia which increased to 177,000 in 2020. Unfortunately, there is no data on the number of tower crane accidents in Indonesia. Tower crane safety issues can be regarded as complex sociotechnical system problems with multiple technological, environmental, and societal components. The tower crane is always in high-frequency usage after structural safety checks and site assembly (Zhou et al., 2018).

After seeing the example above, Indonesia's industrial accident rate is still very high, especially necessary to analyse the construction safety plan for tower cranes. This research will conduct an occupational safety analysis of tower crane work as part of the construction safety plan, as well as a case study on the construction of the building project of Alma Ata University in Bantul, Yogyakarta using Construction Safety Analysis.

Alma Ata is one of the universities in Yogyakarta. Currently, a new 9-stories building is being built on the campus which has 5 faculties. The new building was later called Al-Mustofa. This development is under PT. Muara Mitra Mandiri as main contractor.

Construction Safety Analysis, hereinafter referred to as CSA, is an important element in the risk management system. Construction safety analysis also known as job safety analysis and job hazard analysis, is a technique that involves the analysis of the main tasks in the job and identifying the risks and determining the safety ways to perform those tasks. Based on CSA, risk assessment is considered the process of estimating the likelihood of an event and

the importance or severity of its harmful effects. In addition to risk assessment, this process allows the team to understand the minimum risks in the system and propose appropriate control measures (Sadat et al., 2019). It is necessary to research cranes which are expected to provide guidance to identify and control risks to reduce the possibility of injury in the workplace.

1.2 Problem Statement

The problem statements of this research are:

1. What are the potential hazards that can be identified in lifting and transporting activities using a freestanding tower crane?
2. How to control these potential hazards using Construction Safety Analysis method?

1.3 Research Objectives

The objectives of this research are:

1. Identify potential hazards in lifting and transporting activities using freestanding tower cranes.
2. Determine actions to be taken to control potential hazards work accidents.

1.4 Significant of Research

Primarily, based totally on the description above, the advantages of this research are as follows:

1. For Researchers

   This research is predicted to feature perception in the development protection plan and emerge as an example of the way to observe occupational protection and fitness in production tasks.

2. For contractors or implementers:

   This research may be used as a manual to become aware of and manipulate dangers in high-upward push constructing tasks from the factor of view of the supervisory consultant.

3. For the government:

   This research is predicted to contribute to thought in identifying, controlling, and minimizing the danger of labour injuries in tower crane work.

1.5 Scope and Limitation of the Research

To conform to the expected goals, the research obviously has certain limitations. This research only focused on creating the Construction Safety Analysis form of the work of tower cranes in the building project of Alma Ata University, Yogyakarta and was verified only by construction safety and risk experts.

CHAPTER II
LITERATURE REVIEW

2.1 Previous Research

Sadat et al (2019) investigated entitled Application of Job Safety Analysis and Inspecting the Changes in Identification of Hazards in a Cement Industry in Fars Province in 2017. The method of this study is cross-sectional study. The most highly rated cause of the accident among the assessed hazards was humans' error with a value of 37.1%. Economic outcomes (56.1%) were ranked higher than human and environmental outcomes, and human causes (58.9%) were ranked higher than management, design, and structural reasons. In addition, management changes (55.3%) prioritized design and structural changes.

Hamid et al (2019) investigated entitled Causes of Crane Accidents at Construction Sites in Malaysia. The method used in this study is data analysis. The results obtained from this study are three aspects that can exaggerate the number of crane accidents in Malaysia: the type of crane, the states involved in the crane accident, and the type of crane accident in Malaysia. A mobile crane involved in a crane accident that caused 23 accidents in Malaysia. Overturned cranes represent the highest type of crane accident at 39% in the last 6 years. Based on data analysis, structural failures are the main cause of crane accidents in Malaysia, with 28 causes.

Jiang et al (2021) investigated entitled System Hazard Analysis of Tower Crane in Different Phases on Construction Site. This research uses qualitative and primarily suitable analysis. The method used in this study is IDEF0. IDEF0 is one of the IDEF (ICAM Definition Method) developed by the US Air Force's ICAM (Integrated Computer-aided Manufacture), also used STAMP (System-Theoretic Accident Model and Process) and STPA (System Theoretic Process Analysis) to system hazard analysis based on STAMP model. This research analyses the entire process of a tower crane at this construction site. The dangers of each phase are identified by systematic analytical methods. Research has shown that STAMP in

combination with IDEF0 is an effective method for risk analysis in various phases. IDEF0 can provide STAMP system inputs, outputs, and related elements. STAMP models the system based on components and processes. In general, the dangers posed by tower cranes that can occur at various stages of a construction site have been analysed.

Palega (2021) investigated entitled Application of the Job Safety Analysis (JSA) Method to Assessment Occupational Risk at the Workplace of the Laser Cutter Operator. The method of this research is estimated risk level using two parameters: consequences of the event and probability of the consequences of the event. The result of this research is systematic oversight is required to maintain acceptable levels of identified occupational hazards. Applied technical and organizational security measures. In this regard, it is also important to be sensitive to employees and pay attention to special circumstances. The absence of non-compliance with the precautions listed on the risk assessment card increases the likelihood of an occupational or occupational accident and, as a result, raises the risk category to an unacceptable level.

2.2 Current Research

Comparison of previous and current research can be seen in Table 2.1.

Table 2.1 Comparison of Previous and Current Research

Previous Research						**Current Research**
No	**Aspect**	**Sadat et al** (2019)	**Hamid et al** (2019)	**Jiang et al** (2021)	**Palega** (2021)	**Amilia** (2023)
1	Research Title	Application of Job Safety Analysis and Inspecting the Changes in Identification of Hazards in a Cement Industry in Fars Province in 2017	Causes of Crane Accidents at Construction Sites in Malaysia	System Hazard Analysis of Tower Crane in Different Phase on Construction Site	Application of the Job Safety Analysis (JSA) Method to Assessment Occupational Risk at the Workplace of the Laser Cutter Operator	Application of Construction Safety Analysis (CSA) Method to Assess Occupational Risk in Lifting and Transporting Activities Using Freestanding Towe Crane

Table 2.2 Comparison of Previous and Current Research (continued)

Previous Research						Current Research
No	**Aspect**	**Sadat et al** (2019)	**Hamid et al** (2019)	**Jiang et al** (2021)	**Palega** (2021)	**Amilia** (2023)
2	Research Objectives	Management of identified hazards, Reducing the number of accidents in each subunit, Identifying the changes made at the factory, and improving the safety of the central cement plant in the country.	To find out what aspects affect crane accidents at construction sites in Malaysia.	Investigation of hazard characteristics and propagation at various construction stages of tower cranes.	Analyze and determine occupational risk levels and determine actions to be taken to reduce or eliminate the adverse effects of work environment factors on the human body and reduce the likelihood of accidents and dangerous illnesses.	Identify potential hazards in lifting and transporting activities using freestanding tower cranes and determine actions to be taken to control potential hazards work accidents
3	Methods	Descriptive Method and Job Safety Analysis (JSA).	Data analysis using frequency distribution analysis and content analysis method.	IDEF0 (ICAM Definition Method), STAMP (System-Theoretic Accident Model and Process), and STPA (System Theoretical Process Analysis).	Job Safety Analysis method (JSA) with Consequences of the event and probability of the consequences of the event as parameters.	Construction Safety Analysis (CSA)

Table 2.3 Comparison of Previous and Current Research (continued)

Previous Research						Current Research
No	**Aspect**	**Sadat et al** (2019)	**Hamid et al** (2019)	**Jiang et al** (2021)	**Palega** (2021)	**Amilia** (2023)
4	Research Result	The most highly rated cause of the accident among the assessed hazards was humans' error with a value of 37.1%. Economic outcomes (56.1%) were ranked higher than human and environmental outcomes, and human causes (58.9%) were ranked higher than management, design, and structural reasons. In addition, management changes (55.3%) prioritized design and structural changes.	Three aspects that can exaggerate the number of crane accidents in Malaysia: the type of crane, the states involved in the crane accident, and the type of crane accident in Malaysia. A mobile crane involved in a crane accident that caused 23 accidents in Malaysia. Overturned cranes represent the highest type of crane accident at 39% in the last 6 years. Based on data analysis, structural failures are the main cause of crane accidents in Malaysia, with 28 causes.	Analyses the entire process of a tower crane at this construction site. The dangers of each phase are identified by systematic analytical methods. Research has shown that STAMP in combination with IDEF0 is an effective method for risk analysis in various phases. IDEF0 can provide STAMP system inputs, outputs, and related elements. STAMP models the system based on components and processes. In general, the dangers posed by tower cranes that can occur at various stages of a construction site have been analysed.	Systematic oversight is required to maintain acceptable levels of identified occupational hazards. Applied technical and organizational security measures. In this regard, it is also important to be sensitive to employees and pay attention to special circumstances. The absence of non-compliance with the precautions listed on the risk assessment card increases the likelihood of an occupational or occupational accident and, as a result, raises the risk category to an unacceptable level.	

Based on Table 2.1 above, this study is different from the previous study. That are the year of the survey, the location of the survey, the topic, and the subject of the survey. This study uses a case study from the building project of Alma Ata University in Yogyakarta to prepare a Construction Safety Analysis (CSA) for lifting freestanding tower crane.

CHAPTER III
THEORETICAL BASIS

3.1 Project

A Project is an endeavor that is undertaken to produce the results that are expected from the requesting part (Marlin, 2000). The quality of the project should correspond to the satisfaction of the owner.

According to Kerzner (2009), "A project can be considered to be any series of activities and tasks that: have a specific objective to be completed within certain specifications, have defined start and end dates, have funding limits (if applicable), consume human and nonhuman resources (i.e., money, people, equipment), are multifunctional (i.e., cut across several functional lines)."

A construction project is an activity to achieve a goal (building or structure) within a specified time, cost, and quality constraint. Construction projects consist of the construction of transportation infrastructures such as roads, railways, and airports; water infrastructure such as dams and bridges; and buildings and residential construction.

3.2 Construction Project

The construction project is an activity that has the aim of constructing a building that requires resources (such as costs, labor, materials, and equipment) which are carried out in detail and a planned manner. The cost involved in a construction project varies, depending on what building will be built. These costs include labor salary, material needs, and rental of heavy equipment.

Heavy equipment is needed for construction such as high-rise buildings, bridges, and roads. the heavy equipment used also adapts to the construction of what is being done. In the construction of high-rise buildings, the heavy equipment used is divided based on the type of work required. Based on Modul Building Construction Engineering by Indonesia Public Works Department, heavy equipment for building construction work includes:

1. Tool and earth diggers

   In this work, the heavy equipment used is:

   a) Bulldozer that serves to push soil, gravel, or other details from one place to another that has been determined.
   b) Loader which serves to load the soil. gravel or other grains into the conveyance.
   c) Backhoe Loader that has a dual function. The front serves as a loader while the back functions as a shovel or backhoe.
   d) Backhoe shovel or Excavator that has the main function of digging soil and loading it into a truck or filling the soil around the shovel by turning its body without moving.

2. Deep foundation tools

   In this work, the heavy equipment used is:

   a) Foundation Pile Tool using a drop hammer mounted on a crane or drill pile.
   b) Foundation Drill Tool is a drill pole that functions to drill soil to the desired depth without causing vibration and noise such as a drop hammer.

3. Soil compactors

   In this work, the heavy equipment used is:

   a) Three-wheel Roller which is operated on sub-base work but occasionally on finishing with hot mix.
   b) Tandem Roller is used to compact road sub-bases or vehicle parking lots, gravel beds, and hot mix overlayer.
   c) Sheep Foot Roller is mostly used in soil compaction operations, especially in soft and clay soils.
   d) Vibrating Compactor is used to compact soil, including compaction of road bodies or vehicle parking lots.
   e) Vibrating Roller is used to compact the road surface layer or parking lots or paving layers.

4. Transport and equipment for mixing and pouring concrete mix

   In this work, the heavy equipment used is:

a) Truck Mixer is used by ready mixed factory to transport fresh concrete mix to projects that need it.
b) Mobile Concrete Pump is used to pump and pour ready-mixed concrete into the previously prepared formwork.

5. Lifting equipment

   In this work, to do vertical conveyance and horizontal conveyance is using cranes.

3.3 Crane

Heavy equipment is needed to support the construction project. Heavy equipment commonly used in construction projects are bulldozers, trucks, asphalt finishers, excavators, and cranes.

The use of cranes is one of the essential machines in the building construction project. The accuracy of the crane selection has some impact on the profits of the project. Cranes play an important role in construction as they are important in lifting, transporting, and handling materials.

Cranes are commonly used for construction work, namely construction work, bridges, harbours, dams, and jetties. However, the type of crane required depends on the situation. For example, concrete work in a high-rise building requires a large number of cranes, and workers must use the crane that best suits their work. In a two-story office building, mobile cranes can be used for concrete beams, columns, walls, etc., but in multi-story building structures, tower cranes are absolute to complete the concrete work required (Adilah, 2009).

The crane supports a minimum radius and a maximum weight that can be lifted with a jib length. The farther you are from the canter, the more you can't lift. The crane is a tower or derrick with cables and pulleys used to raise and lower the material. Therefore, the crane operator is ultimately responsible for the safety of the crew and the crane.

The fundamental types of cranes are divided into several categories. There are mobile, hydraulic, overhead, gantry, and tower. In Indonesia, especially in tall

building, the types of cranes that are mostly used is a mobile crane and tower crane.

3.3.1 Tower Crane

Lifting, handling, and transporting are rudimentary tasks for any cranes. The crane uses a pulley and cable system to create a mechanical advantage that allows it to lift large loads. There are two most important criteria in the crane design, load capacity and stability. This crane can reach up to 265 feet, out to 230 feet, and lift a total of approximately 20 tons (Skinner & Construction Industry Research and Information Association., 2006).

Tower cranes have various types, there is a free-standing tower crane (this tower crane can reach a height of 100m); tied-in tower crane (this tower crane is tied to the structure of the building under construction. This is usually used for buildings that have a height more than 100m); and rail mounted crane. Although it has various types, the function of three types of tower cranes is to be lifting.

Tower cranes are installed on the ground during the construction phase. Tower cranes are used to lift the material from the underside to the stories that needed it. The most important element that will ensure the tower crane remains is the concrete at the base of the tower crane. Part of the tower crane consists of:

a. Anchor or underframe.
b. Mast (tower) is a vertical pole that stands on a base.
c. Jib (working arm) is the arm part of this heavy equipment composed of an iron frame. The arrangement of the iron frame has a length that determines the horizontal reach of the crane can be achieved.
d. Slewing unit is the portion of the crane that carries the load.
e. Operator’s cab.
f. Climbing frame
g. Concrete counterweight (counter jib) is a component to balance the jib so the tie bar and tower crane can move balanced.
h. Machinery arm lifts the load. It also drives the load and cable.
i. Trolley is a tool that works to shift the direction or material along the jib.
j. Hook is a tool to lift the load move vertically.

3.3.2 Tower Crane Safety Management

The safety management of tower cranes is to be organized and consists of elements that depend on and interact with each other. It also has a certain structure and function.

1. Tower crane stakeholders

   A tower crane is a major piece of equipment used for lifting activities on a construction site. Its stakeholders include the manufacturer, the main contractor, and the subcontractors.

2. Tower crane equipment features

   Tower crane equipment consists of various components, such as metal structures, mechanisms, electrical systems, connecting components, auxiliary equipment and devices, safety, etc. Although there are different types of tower cranes, their main components are the same. After the repeated process of installation, commissioning, and disassembling, tower crane components are subject to aging, corrosion, and wear due to their humid and harsh environment. This shows how important it is to maintain and repair tower crane parts.

3. Tower crane staff

   The major staff of the tower crane on the construction site is the supervisors and the workers. The supervision and guidance of the supervisor of main and subcontractors as well as cooperation between tower crane workers (crane operators, flaggers, dismantlers, and erection/demolition workers) are essential for the safety of tower cranes.

4. Work environment of the tower crane.

   The entire operation of the tower crane is exposed to the outdoor, so various environmental factors affect the safety of the tower crane such as weather, temperature, and working surface. Weather factors can affect the stability of the tower crane structure (i.e., excessive wind force can affect the stability of the tower crane structure) and lifting loads.

5. Work process of the tower crane

   The tower crane process at the construction site includes stages: assembly, operation, and disassembly. The assembly phase defines the structure and function of a stable system. The tower crane is assembled at the construction site by connecting its main parts. The operating phase is the necessary lifting and moving of equipment. While the dismantling phase, it is the opposite of the installation phase.

Different stages of course lead to different safety factors and types of accidents. for example, lifting operations take place during the operating phase. Safety assessments and elevator plans are needed to prevent collisions. Personal protective equipment is essential to reduce the rate of occupational accidents.

3.4 Occupational Health and Safety

According to Article 87 of the Indonesian Labour Law Number 13 (2003), "Every enterprise is under an obligation to apply an occupational health and safety management system that shall be integrated into the enterprise's management system. Rulings concerning the application of the occupational health and safety management system as referred to under subsection shall be determined and specified with a Government Regulation."

According to Article 33 of Regulation of The Minister of Public Works and Public Housing Indonesia Number 10 (2021), "Responsible Construction Service Providers conduct guidance and supervision of the implementation of the construction safety management system as stated in the construction safety management system document."

Occupational health and safety are an effort to prevent the occurrence of diseases or accidents resulting from work and the work environment itself. This is to improve the physical and spiritual integrity of the workforce as an implementation of the second and fifth Pancasila values.

3.5 Risk Management

Risk management of occupational health and safety is an effort to manage risk in a comprehensive, structured, and planned manner with a fixed system to

prevent accidents. The goal of risk management is to identify project risks and develop strategies to either significantly reduce them or take steps to avoid them altogether.

According to Wideman (1992), “The purpose of project risk management is to specifically identify factors that are likely to impact the project objectives of scope, quality, time, and cost; quantify the likely impact of each factor; give a baseline for project noncontrollable; mitigate impacts by exercising influence over project control-labels.”

3.6 Hazard Identification

A hazard is a potential for harm. In practical terms, a hazard often is associated with a condition or activity that, if left uncontrolled, can result in an injury or illness (OSHA 3071, 2002).

Risk is often interpreted in terms of hazards or negative impacts, this Standard is concerned with risk as exposure to the consequences of uncertainty, or potential deviations from what is planned or expected. The process described here applies to the management of both potential gains and potential losses (AS/NZS 4360, 2004).

Hazard identification is the first step in advancing occupational health and safety (OHS) risk management. Hazard identification is systematic work to identify hazards in work activities. Risk identification is the basis of risk management. Hazard identification yields several benefits, among others:

a. Reduce the chance of an accident. Hazard identification minimizes the possibility of accidents because the identification of hazards is related to the factors that cause accidents.
b. Provide education about the potential hazards of the company's activities to increase awareness of the company's operations.
c. As a basis and advice for determining appropriate prevention and safety strategies. By identifying possible hazards, management can prioritize treatment based on the level of risk so that the expected results will be more effective.

d. Provide written information to all parties about the company's dangers. So that people are expected to understand the risks of the business being carried out.

To identify hazards, technology is needed that can solve problems that arise. Several methods have been developed to analyze the possible hazards that could occur. Several methods of hazard identification include:

1. Register audit and check occupational health and safety
2. Preliminary hazard analysis
3. Failure tree analysis
4. "What if" analysis method
5. Effect mode and failure mode analysis method
6. Hazard and operability study
7. Construction Safety Analysis (CSA)
8. Task risk analysis

3.7 Construction Safety Analysis (CSA)

Based on Minister of Public Works and Public Housing Regulation Number 10 of 2021 concerning Guidelines for Construction Safety Management Systems, "Construction safety analysis next one abbreviated as CSA is a method of identifying and control hazards by a chain in the work method statement."

According to OSHA (2002), "Job hazard analysis is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment."

Job safety analysis is an important element in the risk management system. This technique involves the analysis of the main tasks in the job and identifying the risks and determining the safe ways to perform those tasks (Sadat et al., 2019). Jobs that require job safety analysis are:

1. Jobs that are rarely carried out or involve new workers to carry them out.
2. Jobs that have histories or potential for causing injury, near miss, or incident-related loss.
3. Critical work related to safety such as fire, explosion, chemical spill, and others.

4. Jobs carried out in a new environment.
5. Job that has changed the implementation of the work, either method or the like.

According to OSH Academy Course 706 Study Guide (2021), there are four steps to identify hazards using Construction Safety Analysis:

1. Select the job to be analysed

   Job safety analysis can be performed on many jobs. However, there are types of work that are the priority for job safety analysis:

   a. Jobs with a high rate of injury or illness.
   b. Jobs that have the potential to cause severe injury to disability.
   c. High-risk jobs that can cause accidents or serious injury even if only because of a simple human error.
   d. Jobs that are new to your operation or have undergone changes in procedures.
   e. Jobs are complex to require written instructions.

2. Describe the hazard in each step

   A job description is provided that is analyzed first before the work is divided into various work steps. Each job can be divided into steps. Who is working? How many workers? And what the worker does forms the basis for the explanation of each step.

   The job description is used to set up a risk analysis for the job. The results of the analysis are generally reported through the job safety analysis worksheet in a format consisting of three columns: work procedures, the presence of hazards, and precautionary measures or recommendations for safe work practices. An example of a job safety analysis worksheet is shown in the Figure 3.1 below.

No.	Sequence of Work Steps	Hazard Identification				Mitigation	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		

Figure 3.1 Worksheet of Job Safety Analysis

(Source: Regulation of The Minister of Public Works and Public Housing Indonesia Number 10 of 2021)

3. Develop preventive measures

   After reviewing the list of hazards, the next thing to consider is to use hazard control methods that eliminate or reduce hazards. There are two main strategies for permanently or temporarily reducing the risk of injury: eliminating or reducing the risk and controlling exposure to the risk.

   Identification of hazardous conditions and unsafe behavior can be assisted with data available at each work step such as Material Safety Data Sheets (MSDSs), experiences of workers, accident reports, first aid statistical records, and behaviour-based safety (BBS). In addition, the hazard can also be traced through several questions to ensure the existing data.

4. Writing the safe job procedure (SJP)

   Safe job procedures are the final result of a construction safety analysis. Safe working procedures are excellent documentation for use as a lesson plan and become the company's guidelines to improve work safety.

   When determining controls, or considering changes to existing controls, consideration shall be given to reducing the risks according to the following hierarchy: elimination; substitution; engineering control; signage/warnings and/or administrative controls; and personal protective equipment (OHSAS 18001).

   a. Elimination

      Elimination is an ideal step to eliminate the hazard and reduce the likelihood of occupational accidents. This method is difficult to implement and can be very expensive if the work process is already in progress. However, if the work process is still in the planning stage, this method is easy and cheap to do.

   b. Substitution

      Alternative techniques are the replacement of materials, tools, or work methods with others to reduce the chance of an accident.

   c. Engineering Control

      This method is performed by changing the design of the workplace, equipment, or work process to reduce the risk.

d. Administrative Controls

   Risk management in this way, such as creating new work policies or standard operating procedures; monitoring the use of dangerous tools and materials; using alarms and warning signs; and training workers. Unfortunately, this management control requires other control methods.

e. Personal Protective Equipment

   Personal protective equipment is used when engineering control cannot eliminate the hazard. Personal protective equipment can further protect the safety and health of workers.

CHAPTER IV
RESEARCH METHODOLOGY

4.1 Subject and Object of Research

According to Arikunto (2016), “research subjects gave boundaries of research subjects as objects, things or people where data is for variables research is inherent, and that is at issue.” The subject of this research is the building project of Alma Ata.

The object of research in general will map or describe the research area or research objectives comprehensively, which includes regional characteristics, development history, organizational structure, main tasks, and other functions by the mapping of the research area meant (Satibi, 2011). So, the object of this research is lifting and transporting activities of freestanding tower crane in the building project of Alma Ata University. The project location can be seen in the Figure 4.1 below.

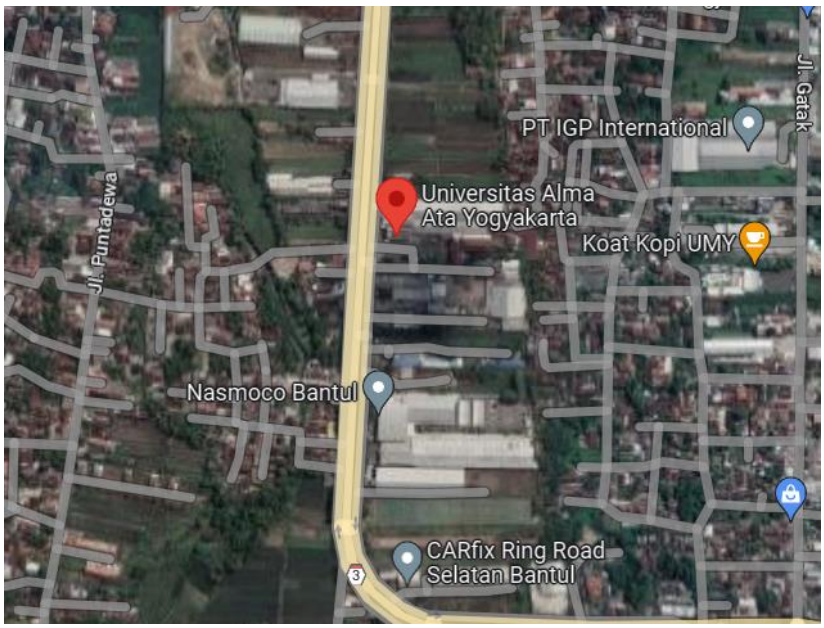


Figure 4.1 Research Location

(Source: Google Maps, 2023)

4.2 Data and Method of Data Collection

Data are the building blocks of scientific research. In scientific research, data are assessed. Through the data, information concerning the group or phenomena investigated is sought. There are two types of data, primary data and secondary data. The primary data are those which are collected afresh and for the first time, and thus happen to be original in character (Kothar, 2014).

Methods of data collection are the methods used to collect research data that is analyzed and processed. This technique for physically obtaining data to be analyzed in a research study. In this research uses two types of data, primary data and secondary data. Primary data is data collected from the subject or object of research and processed by the researcher directly. Primary data can be obtained through observation, questionnaires, and interviews. While secondary data is data obtained indirectly from the subject or object of research. This data can be obtained from various sources with various methods. As for the sources and methods of data collection in this research are as follows.

1. Primary Data

   Primary data are collected and processed directly, such as site observations, surveys, and interviews (Kothar, 2014). To obtain primary data, research is carried out directly from the object. As for the primary data in this research are:

   a. Observation

      Observations are made by visiting the Alma Ata University building project directly. The things observed are mobilization of tower crane operator, tower crane activities in lifting and transporting materials, and demolition of tower crane.

   b. Interview

      Interview or discussions are conducted with HSE expert to obtain results regarding the possibility and impact of occupational health and safety risks that may occur on the object being reviewed. In addition, interview is also conducted when verifying the Construction Safety Analysis (CSA) form by HSE expert. This is done to find out what requires to be revised.

2. Secondary Data

   The secondary data, on the other hand, are those which have already been collected by someone else and which have already been passed through the statistical process (Kothar, 2014). The secondary data used are literature, regulations, and videos that support the research discussion. As for some secondary data used in this research are:

   a. Literature and video review
   b. OHSAS 18001:2007 concerning Occupational Health and Safety Management Systems
   c. OHSAS 18002:2008 concerning Guidelines for The Implementation of OHSAS
   d. Indonesian Law No.1 of 1970 regarding Work Safety
   e. Regulation of The Minister of Public Works and Public Housing Indonesia No. 10 of 2021 concerning Guidelines of Construction Safety Management System
   f. Regulation of The Minister of Manpower Indonesia No. 8 of 2020 concerning Occupational Safety and Health for Lift and Transporting Instruments.

4.3 Data Analysis

The stage of data analysis requires to be carried out systematically so that the results obtained are as expected. The stages of data analysis as follows:

1. Collecting data from literature and video review as reference material to support understanding regarding the topics and objects researched. Literature review carried out such as data collection related to the Construction Safety Analysis (CSA) method and work accidents in tower crane activities.
2. Performing direct observations on the object to be observed. In this stage begin with identifying the tower crane. Next, it will be detailed what work involves tower cranes. In the second stage, the risk and possibility of occupational accidents due to the activity of the tower crane are determined. This phase is the most important in creating a Construction Safety Analysis (CSA) Form.

3. Collecting data based on observations, interviews with HSE expert, literature review, and watch videos about tower cranes.
4. The data that has been collected then analysed to be compared with the implementation carried out in the field, identify hazards that will occur, and take action to control potential hazards.
5. After hazard identification and hazard control measures are made, then compiling the table using the Construction Safety Analysis (CSA) method in accordance with Regulation of The Minister of Public Works and Public Housing Indonesia No. 10 of 2021. So, it becomes Construction Safety Analysis (CSA) Form.
6. Furthermore, the Construction Safety Analysis (CSA) Form that has been made will be checked by HSE expert to verify whether the hazard identification and hazard control are in accordance with what is required. The results of the checks are in the form of verification and revision, if any, to the Construction Safety Analysis (CSA).
7. The Construction Safety Analysis (CSA) Form that has been revised then discussed based on the results of the analysis. After that, conclusions and suggestions are made based on the results of the data that has been analysed.

4.4 Construction Safety Analysis (CSA) Form

In the stages of making the Construction Safety Analysis (CSA) Form, there are three stages that require to be carried out in this research.

1. Sequence of Work Steps Identification

   This stage is carried out by direct observation in the field and aims to obtain information regarding the sequence of tower crane work.
2. Hazard Identification

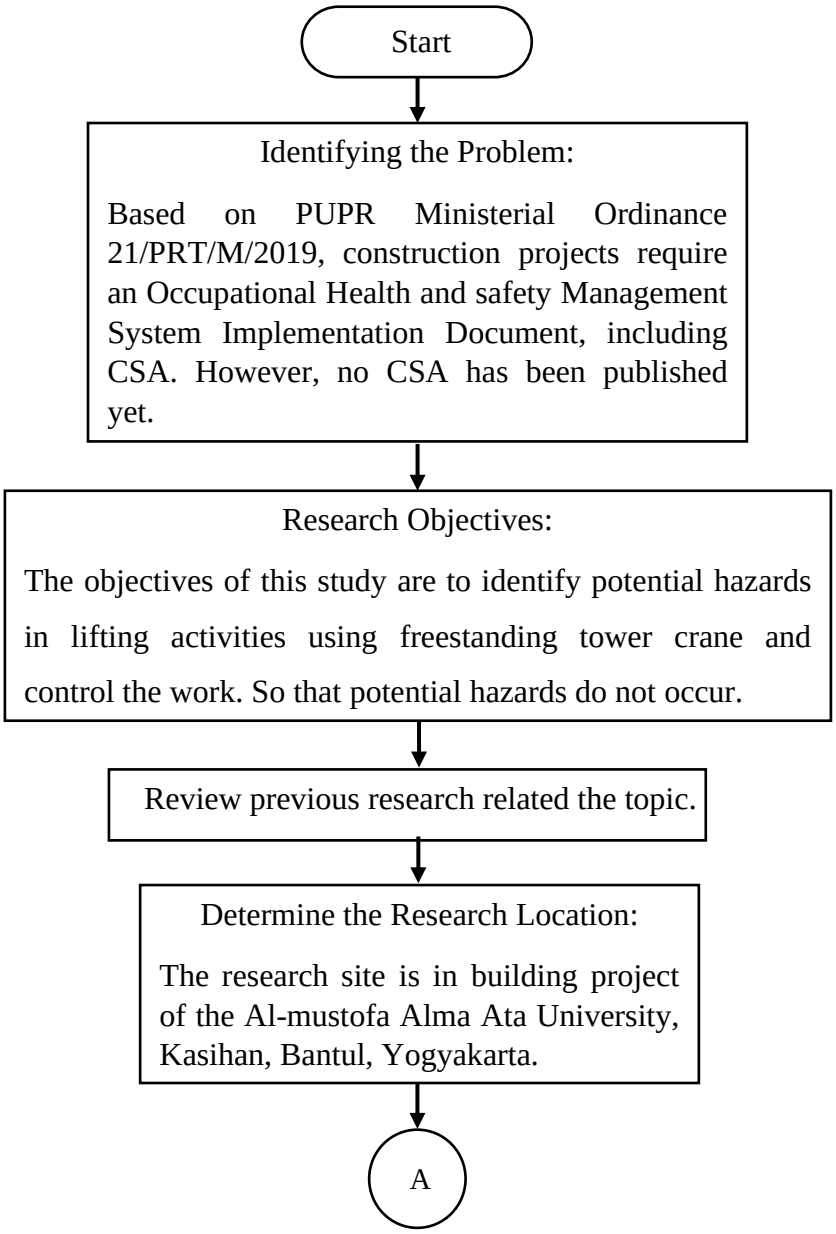
   Hazard identification is carried out together with identification of sequence of work. This stage aims to find out what are the potential hazards that can occur at each step of work.

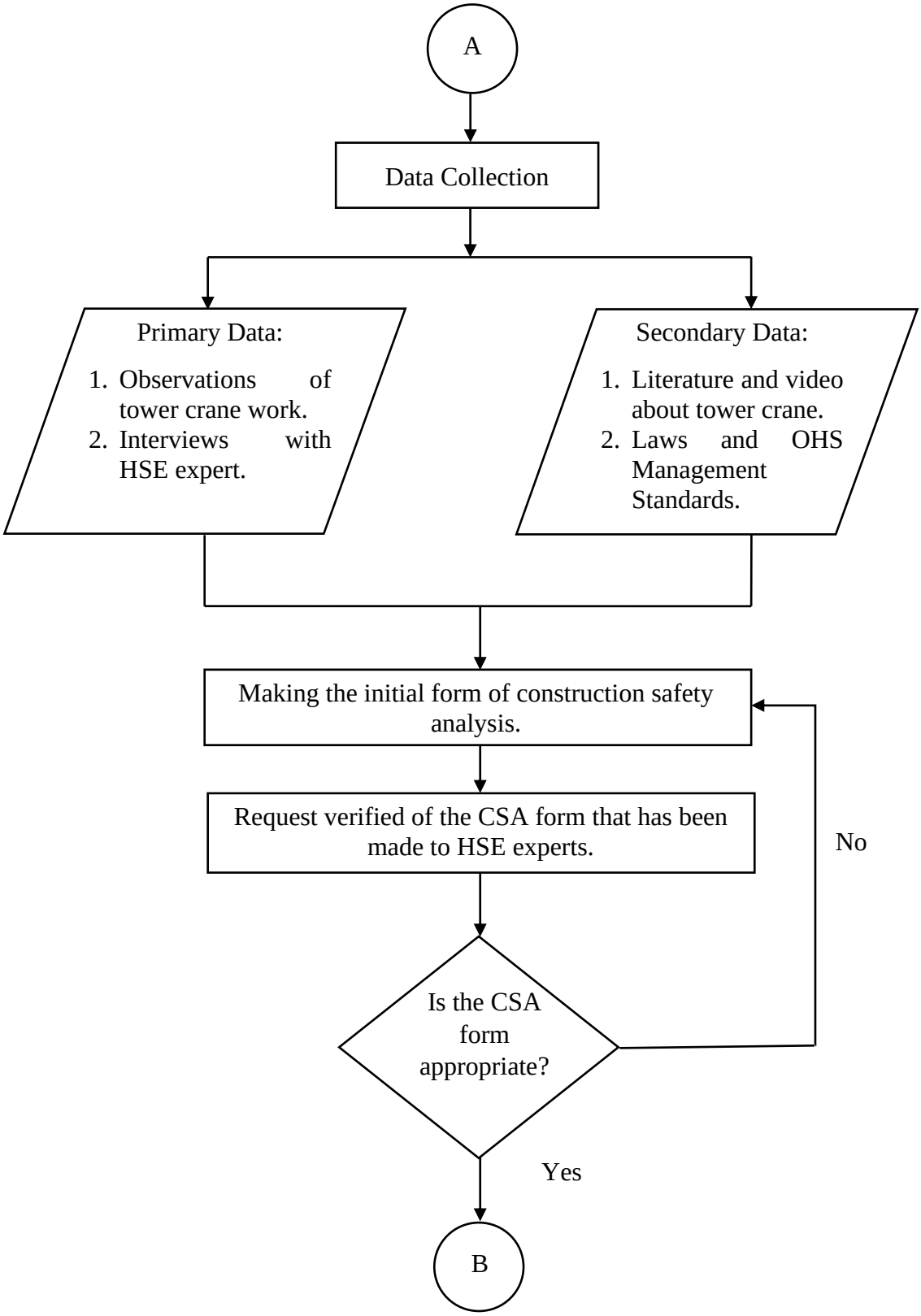
3. Hazard Control

   After obtaining the sequence of work and hazard identification, hazard control is the carried out by compiling the sequence of work and hazard identification in detail based on the results of observations. Hazard control aims to minimize or eliminate work accidents that may occur in every potential hazard that exists.

4.5 Research Flow chart

The sequence of research steps can be seen in Figure 4.2 as follow.




A
Data Collection
Primary Data:
1. Observations of tower crane work.
2. Interviews with HSE expert.
Secondary Data:
1. Literature and video about tower crane.
2. Laws and OHS Management Standards.
Making the initial form of construction safety analysis.
Request verified of the CSA form that has been made to HSE experts.
Is the CSA form appropriate?
No
Yes
B

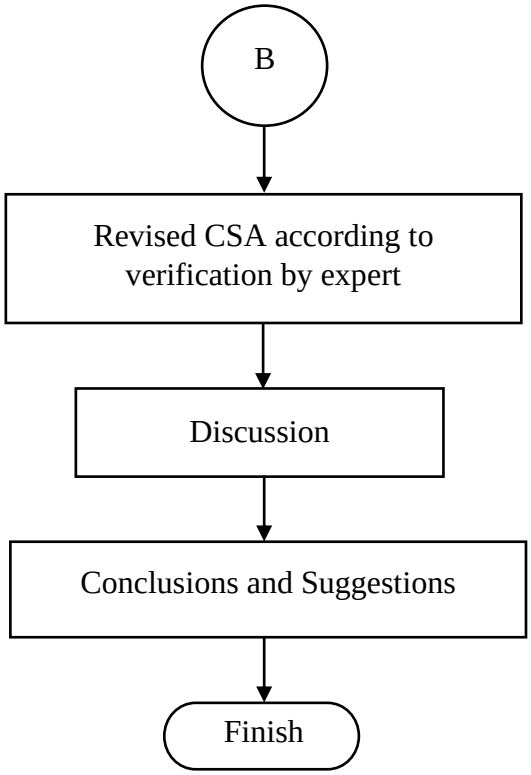


Figure 4.2 Research Flow Chart

CHAPTER V
ANALYSIS AND DISCUSSION

5.1 Project Overview

The construction work of Alma Ata University building is located in Jalan Brawijaya Number 99, Kasihan district, Bantul Regency, Yogyakarta. This project was carried out by PT. Muara Mitra Mandiri and consists of 9 stories with the bottom structure used bored pile foundation and upper structure made of reinforced concrete. In its implementation, this project uses a free-standing tower crane as a lifting activity.

5.2 Observation Object

The object of observation in this research is the tower crane work as follows:

1. Installation of tower crane
2. Operation of tower crane
3. Demolition of tower crane

5.3 Observation Subject

The subject used in this research is the application of Construction Safety Analysis (CSA) method to tower crane work in construction project of Alma Ata University building based on predetermined objects and boundaries.

5.4 Data Analysis

Data analysis was carried out after observation directly in the field. The research stages refer to the Construction Safety Analysis (CSA) method and OHSAS 18002:2008 about safety standards regarding the implementation of occupational health and safety management system.

5.4.1 Identification of Tower Crane Work Steps

The tower crane work in Alma Ata University building construction project has 3 work steps, including:

1. Tower crane installation work
   a. Installation of reinforced concrete foundation for tower crane

      In this work, before casting the foundation, excavation is carried out using an excavator.
   b. Installation of underframes with reinforced concrete foundations

      The tower crane underframe is attached to the reinforced concrete foundation after the tower crane anchors are installed.
   c. Installation of hydraulic climbing

      After the underframe is installed, the next step is to install hydraulic climbing. The hydraulic climbing installation process is assisted by a mobile crane.
   d. Installation of mast section

      The next step after installing hydraulic climbing is installing the mast section to the required height. After reaching the required height, the cabin box is installed using mobile crane.
   e. Installation of counterweight

      This work is carried out after some of the mast section and cabin box were installed. The counterweight functions as a ballast so the tools and materials that will be lifted by the tower crane remain stable and not fall.
   f. Installation of jib

      Jib or working arm is part of this heavy equipment composed of iron frame. The jib installation is assisted by a mobile crane and is carried out after the ballast is installed. After all components on the jib such as hooks, machinery arms, and trolleys are installed, then the installation of mast section is continued up to the desired height.
2. Tower crane operation work
   a. Mobilize the operator to the cabin box

      Operator mobilization to the cabin box is carried out before operating hours begin and after operating hours end. The process of mobilizing operator to the cabin box using ladders installed along the mast section.
   b. Lift and move materials by tower crane

Lifting and moving materials are main activities of tower crane. Before the material is lifted and moved, the first thing that needs to be done is to hook the material onto the available hook. Ater the material is attached to the hook, then the tower crane operator starts lifting the material and moving it to the desired location.

3. Tower crane demolition work
   a. Demolition of mast section

      In this work, first step that must be completed is release the last highest mast section using hydraulic climbing. The mast section that has been removed lowered down by the tower crane hook itself. There is an empty space between the jib and the mast section, so the hydraulic climb and cabin box will be lowered down and merge with the last mast section. This step carried out continuously until jib merge with the first mast section.

   b. Demolition of counterweight

      After demolition of mast section, the next one is demolition of counterweight. Demolition of counterweight is assisted by mobile crane.

   c. Demolition of jib

      Demolition of jib started by demolition of all jib components which are as hooks, machinery arms, and trolleys. Then, demolition of jib which assisted by mobile crane. After demolished the jib, then the demolition of mast section include cabin box and hydraulic climbing is continued until all of mast section demolished.

   d. Demolition of reinforced concrete foundation

      Demolition of reinforcement concrete foundation is carried out to retrieve the underframe which can be reused later.

5.4.2 Hazard Identification of Tower Crane Work

After each tower crane job has been described, then the potential hazard for each job description is identified. This step is included in the Construction Safety Analysis (CSA) method and refers to work, tools, materials, and work environment based on Regulation of The Minister of Public Works and Public Housing Indonesia Number 10 of 2021.

Hazard identification about lifting activity using tower crane is carried out by observation directly in the field, watch the video about tower crane activity, and literature review about tower crane. There are several hazard identifications obtained from observing objects, three of which are:

1. Installation of hydraulic climbing

   This installation is part of installing a tower crane. The hazards that can occur are:

   a. Technicians fall from heights. This happens because workers are tired, unfocused, or not in prime conditions. Besides that, technicians can also fall because safety shoes are slippery and do not use safety belts.
   b. Sling is broken off. This happens because the load being transported exceeds the safety factor of the sling.
   c. Hydraulic climbing fell due to twisting. This happens because the sling broke.
   d. Land subsidence. If the hydraulic climbing falls, it causes the ground to collapse.

2. Tower crane transports and moves materials

   This work is part of operation of tower crane. Tower crane operates during working hours, from 08.00 am to 05.00 pm. The hazards that can occur are:

   a. Workers fall from heights. This happens because the worker is tired, unfocused, or not in prime condition so that when hooking the material onto the tower crane's hook, the worker is dragged along and falls.
   b. Worker is trapped a jib. This source of danger is due to worker working around tower crane's jib traffic area and obstructed view of the operator.
   c. Worker is grazed a jib. This is because the tower crane's operator is not focused due to fatigue or not feeling well. So, the jib grazes and hits the worker.
   d. Workers who working under a tower crane are struck down by material. This happens because the material being transported falls.
   e. Damage materials. Materials that fall while being transported may be damaged.

f. Damage buildings. This happens when the tower crane collapse and falls on the surrounding buildings. In addition, it can also be caused by the operator losing control which causes the jib grazes the building and cause damage.
g. Materials fall on pedestrians around the building. Aside from the material being transported falling and hitting workers who working under the tower crane, the material being transported can also fall and hit pedestrians around the building. This happens when the jib is farthest from the tower crane.

3. Demolition of Jib

In the process of demolition of jib tower crane, there are several hazards that can occur, including:

a. Worker is struck down a jib. This can happen because the demolition of jib is not in the right position. So, the jib falls and hit the workers around it.
b. Bolt loose and out of control. This can happen because the bolts are slippery.
c. Jib falls on pedestrians around the working area. Besides the jib being able to fall and hit on the workers around it, the jib also can fall on pedestrians who are doing activities around the tower crane.
d. Jib fell of guardrail and building around the working area. When demolition of jib, the jib may fall onto the guardrail and surrounding buildings if it is not in the correct position.

In addition to the three examples above, identification of potential hazards at work and other indicators is also obtained based on the results of direct observations. Identification of these potential hazards can be seen in Table 5.1 below.

Table 5.1 Hazard Identification at The Workplace of Tower Crane

No.	Work	Indicator	Hazard
1	Installation of Tower Crane	Installation of reinforced concrete foundation	- Worker loss of concentration. - The hoe is broken.
		Installation of hydraulic climbing	- Worker falls from heights. - Sling is broken off. - Hydraulic climbing fell due to twisting. - Land subsidence because not strong enough to support the load.
		Installation of mast section	- Worker falls from heights. - Sling is broken off. - Mast section fell due to twisting. - Land subsidence because not strong enough to support the load.
		Installation of counterweight	- Worker falls from heights. - Sling is broken off. - Counterweight fell due to twisting. - Counterweight falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Counterweight falls on pedestrians around the working area.

Table 5.1 Hazard Identification at The Workplace of Tower Crane (continued)

No.	Work	Indicator	Hazard
1	Installation of Tower Crane (continued)	Installation of jib	- Worker falls from heights. - Sling is broken off. - Jib fell due to twisting. - Jib falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Jib falls on pedestrians around the working area.
2	Operation of Tower Crane	Operator mobilization to the cabin box	Worker falls from heights.
		Tower crane transports and moves materials	- Worker loss of concentration. - Worker falls from height. - Jib clamps/grazes workers working around the tower crane. - Sling is broken off. - Land subsidence because not strong enough to support the load. - When transporting materials/equipment hits materials, equipment, or buildings. - Materials fell on pedestrians around the working area.

Table 5.1 Hazard Identification at The Workplace of Tower Crane (continued)

No.	Work	Indicator	Hazard
3	Demolition of Tower Crane	Operator climbs the mast towards hydraulic climbing	Worker falls from heights
		Demolition of mast section	- Worker falls from heights. - Sling is broken off. - Mast section fell out due to twisting. - Mast section falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load.
		Demolition of counterweight	- Worker falls from heights. - Sling is broken off. - Counterweight fell out due to twisting. - Counterweight falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Counterweight falls on pedestrians around the working area.
		Demolition of jib	- Worker falls from heights. - Sling is broken off. - Jib falls due to twisting.

Table 5.1 Hazard Identification at The Workplace of Tower Crane (continued)

No.	Work	Indicator	Hazard
	Demolition of Tower Crane (continued)	Demolition of jib (continued)	- Jib falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Jib falls on pedestrians around the working area.

5.4.3 Construction Safety Analysis (CSA) Form Before Verified by An HSE Expert

After the analysis of hazard identification and control measures based on observations and secondary data in the form of literature studies, OHS management standards, OHS-related laws and regulations are implemented, the next step is to prepare a Construction Safety Analysis (CSA) Form for all types of tower crane work. As for the Construction Safety Analysis (CSA) Form that has been made, it can be seen in Tables 5.2 to 5.4.

Table 5.2 Construction Safety Analysis (CSA) Form for Installation of Tower Crane

Construction Safety Analysis (CSA) Form						
Name of Work Permit Applicant	[Name of Executor]			Number	……	
Work of	Installation of Tower Crane			Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY			Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron						
No	**Sequence of Work Steps**	**Hazard Identification**				**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Installation of tower crane foundation	Worker loss of concentration	The hoe is broken			- Workers are given safety induction; - Checking tools; - Checking the SILO and SIO	Supervisor and HSE

Table 5.2 Construction Safety Analysis (CSA)Form for Installation of Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Installation of hydraulic climbing	Worker falls from heights	Sling is broken off	Hydraulic climbing fell due to twisting	Land subsidence because not strong enough to support the load	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the installation of hydraulic climbing; - Installation the signs.	Supervisor and HSE
3	Installation of mast section	Worker falls from heights	Sling is broken off	Mast section fell due to twisting	Land subsidence because not strong enough to support the load	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates;	Supervisor and HSE

Table 5.2 Construction Safety Analysis (CSA) Form for Installation of Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
3	Installation of mast section (continued)					- Supervision during the installation of hydraulic climbing; - Installation the signs.	
4	Installation of counterweight	Worker falls from heights, Counterweight falls on workers working under the tower crane	Sling is broken off	Counterweight fell due to twisting	Land subsidence because not strong enough to support the load, counterweight falls on pedestrians around the working area	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the installation of hydraulic climbing; - Installation the signs	Supervisor and HSE

Table 5.2 Construction Safety Analysis (CSA) Form for Installation of Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
5	Installation of jib	Worker falls from heights, jib falls on workers working under the tower crane	Sling is broken off	Jib fell due to twisting	Land subsidence because not strong enough to support the load, jib falls on pedestrians around the working area	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the installation of hydraulic climbing; - Installation the signs.	Supervisor and HSE

Table 5.3 Construction Safety Analysis (CSA) Form for Operation of Tower Crane

Construction Safety Analysis (CSA) Form						
Name of Work Permit Applicant	[Name of Executor]			Number	……	
Work of	Operation of Tower Crane			Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY			Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron						
No	**Sequence of Work Steps**	**Hazard Identification**				**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Operator mobilization to the cabin box	Worker falls from heights				- Workers are given safety induction; - Checking the SILO and SIO	Supervisor and HSE

Table 5.3 Construction Safety Analysis (CSA) Form for Operation of Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Tower crane transports and moves materials	Worker loss of concentration, worker falls from height, jib clamps/grazes workers working around the tower crane	Sling is broken off	when transporting materials/equipment hits materials, equipment, or buildings	Land subsidence because not strong enough to support the load, Materials fell on pedestrians around the working area	- Using the sling and shackle greater than SF; - Transportation of materials does not exceed the load capacity; - Supervision during the installation of hydraulic climbing; - Installation the signs.	Supervisor and HSE

Table 5.4 Construction Safety Analysis (CSA) Form for Demolition Tower Crane

Construction Safety Analysis (CSA) Form						
Name of Work Permit Applicant	[Name of Executor]			Number	……	
Work of	Demolition of Tower Crane			Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY			Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron						
No	**Sequence of Work Steps**	**Hazard Identification**				**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Operator climbs the mast towards hydraulic climbing	Worker falls from heights.				- Workers are given safety induction; - Checking the SILO and SIO	Supervisor and HSE
2	Demolition of mast section	Worker falls from heights,	Sling is broken off			- Using the sling and shackle greater than SF;	Supervisor and HSE

Table 5.4 Construction Safety Analysis (CSA) Form for Demolition Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Demolition of mast section (continued)	Mast section falls on workers working under the tower crane		Mast section fell due to twisting	Land subsidence because not strong enough to support the load	- Installation the crane stands with layer and plates; - Supervision during the demolition of mast section; - Installation the signs	
3	Demolition of counterweight	Worker falls from heights, Counterweight falls on workers working under the tower crane	Sling is broken off	The counterweight fell out due to twisting	Land subsidence because not strong enough to support the load,	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the demolition of mast section;	Supervisor and HSE

Table 5.4 Construction Safety Analysis (CSA) Form for Demolition Tower Crane (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
3	Demolition of counterweight (continued)				counterweight falls on pedestrians around the working area	- Installation the signs	
4	Demolition of jib	Worker falls from heights	Sling is broken off	Jib falls due to twisting	Land subsidence because not strong enough to support the load, jib falls on pedestrians around the working area	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the demolition of mast section; - Installation the signs	Supervisor and HSE

5.4.4 Construction Safety Analysis (CSA) Form Verification

Verification of the Construction Safety Analysis (CSA) Form is carried out after the author has compiled a potential hazard identification and hazard control in Construction Safety Analysis (CSA) Form. In this stage, the form that has been prepared submitted to the HSE expert, Mr. Baru Leksana, S.T. Based on the results of his observations and the interactive discussion between Mr. Baru and the author, the Construction Safety Analysis (CSA) Form made by the author is in accordance with Regulation of The Minister of Public Works and Public Housing Indonesia Number 10 of 2021. However, there are several things that require to be corrected and added to make it more appropriate and in accordance with the conditions in the field.

5.4.5 Hazard Identification of Tower Crane Work After Verified by An HSE Expert

After verification by an HSE expert, there are several identifications that are not quite right or have not been written by the author. To find out the difference between hazards identification before verification, the word provided a blue colour for additional hazard identification and a green colour for hazard identification changed. The hazard identification after verified can be seen in Table 5.5 below.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision

No.	Work	Indicator	Hazard
1	Installation of Tower Crane	Installation of reinforced concrete foundation	- Worker loss of concentration. - Worker slipped into the excavation. - The excavator is broken. - The wrench is broken. - Cast foundation spilled.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision (continued)

No.	Work	Indicator	Hazard
1	Installation of Tower Crane (continued)	Installation of underframe with reinforced concrete foundation	- The underframe falls on/pins down the worker. - The wrench is broken. - Bolt loose and out of control. - The underframe is broken or stuck.
		Installation of hydraulic climbing	- Technician falls from heights. - Sling is broken off. - Hydraulic climbing fell due to twisting. - Land subsidence because not strong enough to support the load.
		Installation of mast section	- Technician falls from heights. - Sling is broken off. - Mast section fell due to twisting. - Land subsidence because not strong enough to support the load.
		Installation of counterweight	- Technician falls from heights. - Sling is broken off. - Counterweight fell due to twisting.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision (continued)

No.	Work	Indicator	Hazard
1	Installation of Tower Crane (continued)	Installation of counterweight (continued)	- Counterweight falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Counterweight falls on pedestrians around the working area.
		Installation of jib	- Technician falls from heights. - Sling is broken off. - Jib fell due to twisting. - Jib falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Jib falls on pedestrians around the working area.
2	Operation of Tower Crane	Operator mobilization to the cabin box	The technician falls from heights.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision (continued)

No.	Work	Indicator	Hazard
2	Operation of Tower Crane (continued)	Tower crane transports and moves materials (continued)	- Worker loss of concentration. - Worker falls from height. - Jib clamps/grazes workers working around the tower crane. - Workers who working under tower crane are struck down by materials. - Sling is broken off. - Land subsidence because not strong enough to support the load. - When transporting materials/equipment hits materials, equipment, or buildings. - Materials fall on pedestrians around the working area.
3	Demolition of Tower Crane	Technicians climb the mast towards hydraulic climbing	Technician falls from heights
		Demolition of mast section	- Technician falls from heights. - Sling is broken off. - Bolt loose and out of control.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision (continued)

No.	Work	Indicator	Hazard
3	Demolition of Tower Crane (continued)	Demolition of mast section (continued)	- Mast section fell out due to twisting. - Land subsidence because not strong enough to support the load. - Mast section falls on pedestrians around the working area.
		Demolition of counterweight	- Technician falls from heights. - Counterweight falls on workers working under the tower crane. - Sling is broken off. - Counterweight fell out due to twisting. - Land subsidence because not strong enough to support the load. - Counterweight falls on pedestrians around the working area.
		Demolition of jib	- Technician falls from heights. - Sling is broken off. - Bolt loose and out of control. - Jib fell out due to twisting.

Table 5.5 Hazard Identification at The Workplace of Tower Crane After Revision (continued)

No.	Work	Indicator	Hazard
3	Demolition of Tower Crane (continued)	Demolition of jib (continued)	- Jib falls on workers working under the tower crane. - Land subsidence because not strong enough to support the load. - Jib falls on pedestrians around the working area. - Jib fell of guardrail and buildings around the working area.
		Demolition of reinforced concrete foundation	- Workers hit by jack drill. - The jack drill is broken. - Materials are struck down by anchor and pieces of concrete.

5.4.6 Construction Safety Analysis (CSA) Form After Verified by An HSE Expert

After revising the identification and potential hazard control, the next step is to make a new Construction Safety Analysis (CSA) Form according to what has been revised by the HSE expert. There are several revisions and additions to the Construction Safety Analysis (CSA) Form. Components that have changed or corrected the word will be given the green colour. While components that have been added will be given the blue colour. This is done to make it easier to see the differences in Construction Safety Analysis (CSA) Form that have not been revised and those that have been revised also verified by HSE expert, it can be seen in Tables 5.6 to 5.8.

Table 5.6 Construction Safety Analysis Form for Installation of Tower Crane After Revision

Construction Safety Analysis (CSA) Form						
Name of Work Permit Applicant	[Name of Executor]			Number	……	
Work of	Installation of Tower Crane			Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY			Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron						
No	**Sequence of Work Steps**	**Hazard Identification**				**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Installation of tower crane reinforced concrete foundation	Worker loss of concentration, worker slipped into the excavation	The excavator is broken, iron lock is broken	Cast foundation spilled		- Workers are given safety induction; - Checking tools; - Checking the SILO and SIO Excavator	Supervisor and HSE

*Each component that has been revised are marked in green and has been added are marked in blue.

Table 5.6 Construction Safety Analysis Form for Installation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Installation of underframe with reinforced concrete foundation	The concrete falls on/pins down the worker	The iron lock is broken, bolt loose and out of control, the underframe is broken or stuck			- Workers are given safety induction; - Checking tools; - Checking the SIO and SILO Technician	Supervisor and HSE
3	Installation of hydraulic climbing	Technician falls from heights	Sling is broken off	Hydraulic climbing fell due to twisting	Land subsidence because not strong enough to support the load	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates;	Supervisor and HSE

*Each component that has been revised are marked in green and has been added are marked in blue.

Table 5.6 Construction Safety Analysis Form for Installation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
3	Installation of hydraulic climbing (continued)					- Supervision during the installation of hydraulic climbing; - Installation the signs	
4	Installation of mast section	Technician falls from heights	Sling is broken off	Mast section fell due to twisting	Land subsidence because not strong enough to support the load	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the installation of mast section; - Installation the signs	Supervisor and HSE

*Each component that has been revised are marked in green.

Table 5.6 Construction Safety Analysis Form for Installation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
5	Installation of counterweight	Technician falls from heights, Counterweight falls on workers working under the tower crane	Sling is broken off	Counterweight fell due to twisting	Land subsidence because not strong enough to support the load, counterweight falls on pedestrians around building	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the installation of counterweight; - Installation the signs	Supervisor and HSE
6	Installation of Jib	Technician falls from heights,	Sling is broken off	Jib fell due to twisting		- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates;	Supervisor and HSE

*Each component that has been revised are marked in green.

Table 5.6 Construction Safety Analysis Form for Installation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
6	Installation of Jib (continued)	jib falls on workers working under the tower crane.			Land subsidence because not strong enough to support the load, jib falls on pedestrians around building	- Supervision during the installation of jib; - Installation the signs	

Table 5.7 Construction Safety Analysis Form for Operation of Tower Crane After Revision

Construction Safety Analysis (CSA) Form					
Name of Work Permit Applicant	[Name of Executor]		Number	……	
Work of	Operation of Tower Crane		Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY		Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron					
No	**Sequence of Work Steps**	**Hazard Identification**			**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Operator mobilization to the cabin box	The technician falls from heights				- Workers are given safety induction; - Checking the SILO and SIO Operator;	Supervisor and HSE

*Each component that has been revised are marked in green.

Table 5.7 Construction Safety Analysis Form for Operation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
1	Operator mobilization to the cabin box (continued)					- Test and check PJK3 DISNAKER before the tool is operated; - OHS checking by PJK3 after the tool is installed	
2	Tower crane transports and moves materials	Worker loss of concentration , worker who working under tower crane are struck down by materials	Sling is broken off		Land subsidence because not strong enough to support the load,	- Using the sling and shackle greater than SF; - Transportation of materials does not exceed the load capacity;	Supervisor and HSE

*Each component that has been added are marked in blue.

Table 5.7 Construction Safety Analysis Form for Operation of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Tower crane transports and moves materials (continued)	worker who working under tower crane are struck down by materials		when transporting materials/equipment hits materials, equipment, or buildings,	materials fall on pedestrians around the building	- Supervision during the operation of tower crane; - Tower crane regular checkup every week by tower crane technician; - Using communication tool (HT); - Code of signs and cues must be clear and understandable; - Periodic maintenance; - Installation the signs	

*Each component that has been added are marked in blue.

Table 5.8 Construction Safety Analysis Form for Demolition of Tower Crane After Revision

Construction Safety Analysis (CSA) Form						
Name of Work Permit Applicant	[Name of Executor]			Number	……	
Work of	Demolition of Tower Crane			Supervisor	[Name of Supervisor]	
Job Date	DD/MM/YYYY-DD/MM/YYYY			Department	[Name of Department]	
Personal Protective Equipment Used to Carry Out the Work: ☑ Safety Helmet ☑ Safety Vest ☐ Face Shield ☐ Others …… ☑ Safety Shoes ☑ Full Body Harness ☐ Earmuffs ☐ Others …… ☑ Safety Gloves ☐ Safety Glasses ☐ Ear Plug ☐ Respiratory ☑ Mask ☐ Appron						
No	**Sequence of Work Steps**	**Hazard Identification**				**Hazard Controls**	**Responsible Person**
		Work	**Equipment**	**Materials**	**Environment/ Public Safety**		
1	Technicians climb the mast towards hydraulic climbing	Technician falls from heights				- Technicians are given safety induction; - Checking tools; - Checking the SILO and SIO Technician	Supervisor and HSE

*Each component that has been revised are marked in green.

Table 5.8 Construction Safety Analysis Form for Demolition of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
2	Demolition of mast section	Technician falls from heights	Sling is broken off, bolt loose and out of control	Mast section fell due to twisting	Land subsidence because not strong enough to support the load, mast section falls on pedestrians around the working area	- Using the sling and shackle greater than SF; - Installation the crane stands with layer and plates; - Supervision during the demolition of counterweight; - Using communication tool (HT); - Installation the signs	Supervisor and HSE
3	Demolition of counterweight	Technician falls from heights,	Sling is broken off,	Counterweight fell due to twisting		- Using the sling and shackle greater than SF;	Supervisor and HSE

*Each component that has been revised are marked in green and has been added are marked in blue.

Table 5.8 Construction Safety Analysis Form for Demolition of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
3	Demolition of counterweight (continued)	worker is struck down counterweight	bolt loose and out of control		Land subsidence because not strong enough to support the load, counterweight falls on pedestrians around the working area	- Installation the crane stands with layer and plates; - Supervision during the demolition of counterweight; - Using communication tool (HT); - Installation the signs	
4	Demolition of jib	Technician falls from heights,	Sling is broken off,	Jib climbing fell due to twisting	Land subsidence,	- Using the sling and shackle greater than SF;	Supervisor and HSE

*Each component that has been revised are marked in green and has been added are marked in blue.

Table 5.8 Construction Safety Analysis Form for Demolition of Tower Crane After Revision (continued)

No	Sequence of Work Steps	Hazard Identification				Hazard Controls	Responsible Person
		Work	Equipment	Materials	Environment/ Public Safety		
4	Demolition of jib (continued)	worker is struck down jib	bolt loose and out of control		jib falls on pedestrians around the walking area, jib fell of guardrail and buildings around the working area	- Installation the crane stands with layer and plates; - Supervision during the demolition of jib; - Using communication tool (HT); - Installation the signs	
5	Demolition of reinforced concrete foundation	Workers hit by jack drill	The jack drill is broken	Materials are struck down by anchor and pieces of concrete		- Checking equipment (jack drill); - Supervision during the demolition of foundation concrete; - Installation the signs	Supervisor and HSE

*Each component that has been added are marked in blue.

5.4.7 Hazard Control of Workplace of Tower Crane

After identifying the hazards in each job, then hazard control is carried out based on the safety standard of OHSAS 18002:2008 the control hierarchy. Recapitulation of potential hazards identification in tower crane work before verified and after verified can be seen in Table 5.9 and 5.10 below.

Table 5.9 Recapitulation of Potential Hazards Identification at The Workplace of Tower Crane Before Verified

No	Hazard
1	Worker loss of concentration
2	The hoe is broken
3	Worker falls from heights
4	Sling is broken off
5	Hydraulic climbing fell due to twisting
6	Land subsidence because not strong enough to support the load
7	Mast section fell due to twisting
8	Counterweight fell due to twisting
9	Counterweight falls on workers working under the tower crane
10	Counterweight falls on pedestrians around building
11	Jib fell due to twisting
12	Jib falls on workers working under the tower crane
13	Jib falls on pedestrians around the building
14	Jib clamps/grazes workers working around the tower crane
15	When transporting materials/equipment hits materials, equipment, or buildings
16	Materials fell on pedestrians around the building
17	Mast section falls on workers working under the tower crane

Table 5.10 Recapitulation of Potential Hazards Identification at The Workplace of Tower Crane After Verified

No	Hazard
1	Worker loss of concentration
2	Worker slipped into the excavation
3	The excavator is broken
4	The wrench is broken
5	Cast foundation spilled
6	The underframe falls on/pins down the worker
7	Bolt loose and out of control
8	The underframe is broken or stuck
9	Technician/worker falls from heights

Table 5.10 Recapitulation of Potential Hazards Identification at The Workplace of Tower Crane After Verified (continued)

No	Hazard
10	Sling is broken off
11	Hydraulic climbing fell due to twisting
12	Land subsidence because not strong enough to support the load
13	Mast section fell due to twisting
14	Counterweight fell due to twisting
15	Counterweight falls on workers working under the tower crane
16	Counterweight falls on pedestrians around working area
17	Jib fell due to twisting
18	Jib falls on workers working under the tower crane
19	Jib falls on pedestrians around building
20	Jib clamps/grazes workers working around the tower crane
21	Workers who working under tower crane are struck down by materials
22	When transporting materials/equipment hits materials, equipment, or buildings
23	Materials fall on pedestrians around the building
24	Mast section falls on pedestrians around the working area
25	Jib fell of guardrail and buildings around the working area
26	Worker hit by jack drill
27	The jack drill is broken
28	Materials are struck down by anchor and pieces of concrete

Based on Table 5.9 and 5.10, there is difference number of hazard types between potential hazard identification before verified and after verified by HSE expert. Total potential hazards identification before verification is 17 types and total potential hazards identification after verification is 28 types. There are differences in total potential hazards because there are several hazard identifications that have not been written down.

From 28 types of hazards identification, it can be classified into 4 types of accidents. The following is an analysis of hazard control from the types of accidents that exist.

1. Technician and worker loss concentration, slipped, and fall from heights

   In tower crane work, both during installation, operation, and demolition, there are potential hazards for technician and worker loss concentration, slipped, and fall from heights. Technician and worker can fall from heights during the

process of installing, operating, and demolishing tower crane. While the worker can slip into the excavation during the process of making the tower crane foundation. The main factor causing this potential hazard is the negligence of the workers themselves. Of course, these hazards can cause injuries ranging from minor to severe injuries. To control this potential hazard is using administration method.

Administration method are carried out by means of toolbox meeting, safety induction, use of PPE, and checking health conditions before workers start work. This is based on Indonesian Law No.1 of 1970 article 8 concerning the obligation to examine the health of body, mental condition, and physical condition of workers. In addition, inspection of PPE is also required in accordance with Indonesian Law No.1 of 1970 article 13 concerning the obligation to comply with all work safety instructions and use PPE. PPE that must be used by workers to avoid the danger of falling from heights or depths is a safety helmet, safety shoes, safety gloves, safety vest, full body harness, and mask. In addition to PPE, technicians and tower crane operator requires to check the expertise of technicians and operator before starting work. Technicians and operator must have SILO (Operator Worthy License) and SIO (Operator License) which are licenses and competency certificates in their fields. This is based on Regulation of The Minister of Manpower Indonesia No. 8 of 2020 article 142 concerning qualification of lifting and transport equipment operators and article 144 concerning qualification of lifting and transport equipment technicians.

2. Technician and worker trapped, struck down, and grazed

   Other potential hazards that can befall technicians and workers besides falling are:

   a. Worker is trapped by tower crane's jib because work around the traffic area of tower crane's jib and obstructed view of the operator. So, it does not see any worker around the jib track.
   b. Technicians and workers are struck down by equipment and materials because technicians and workers are exhausted so resulting in a loss of self-

focus, slings that broken because it is damaged and unable to withstand the load, and workers who are less alert when the tower crane transports easily falling materials such as rocks and sand.

c. Worker was grazed by tower crane's jib because the tower crane operator was tired and unfocused, so the tower crane's jib hit the worker.

The hazards mentioned above can cause losses both in terms of material and workers. The risks that can be experienced by workers are injured, broken bones, disability, and death. Hazard control is carried out by substitution and administration method. Substitution method is carried out by replacing damaged tools and checking wire rope slings periodically. This is based on Regulation of The Minister of Manpower Indonesia No. 8 of 2020 article 131 concerning specifications and prohibitions on the use of defective wire rope slings. As for administration method by carrying out direct supervision both during installation, operation, and demolition of tower cranes. Moreover, based on Indonesian Law No.1 of 1970 article 8 and 13, it is necessary to implement of toolbox meeting, safety induction, use of PPE, and checking health conditions before workers start work.

3. Equipment fell down and damaged

Tower crane has a potential hazard of falling equipment such as hydraulic climbing, mast section, counterweight, and jib that fall due to twisting. Installation and removal of bolts can also cause the bolts to fall out of control. This can cause damage to equipment that falls, land subsidence, equipment falls on workers and people around the working area. It also damages to buildings that are around the working area. Therefore, it is necessary to carry out hazard control with substitution, engineering control, and administration methods. The substitution method is in the form of checking slings periodically and replacing slings when they are damaged according to Regulation of the Minister of Manpower Indonesia No. 8 of 2020 article 131. Engineering controls are carried out by using slings and shackles bigger than safety factor (SF) and installing crane stand with layer and plates. For the Administration method, it is carried out by directly supervising all tower crane activities and

implementing Indonesian Law No. 1 of 1970 articles 8 and 13 by conducting toolbox meetings, safety induction, use of PPE, and checking health conditions before workers start work. Maintenance of tower crane equipment also requires to be carried out in accordance with Regulation of The Minister of Manpower Indonesia No. 8 of 2020 article 155 concerning occupational health and safety of lifting and transport equipment.

4. Materials are fell down, broken, or spilled

   Potential materials are fell down, broken, or spilled can occur in the work of transporting and moving materials using a tower crane or during the process of installing reinforced concrete foundations. Many factors cause material to fall and be damaged when transporting and moving material using a tower crane:

   a. The transportation of material that exceeds the load capacity, the use of standard slings or less than SF, and broken slings. This can cause falling material to damage buildings around the working area, the land subsidence, fall on workers and people around the working area and cause injuries ranging from mild to severe injuries. Engineering controls can be exercised on this hazard by using larger slings and shackles from the SF and installation crane stands with layers and plates.
   b. Materials are spilled because the workers did not give proper directions for the concrete channel from the mixer truck. These hazards can be anticipated by using administration method. Administration method is carried out by providing toolbox meeting, safety induction, checking health conditions before workers start work based on Indonesian Law No.1 of 1970 article 8, and use PPE to carry out hazard risk control based on Indonesian Law No. 1 of 1970 article 13. In addition, maintenance of tower cranes is also carried out based on Regulation of The Minister of Manpower Indonesia No. 8 of 2020 article 155 concerning occupational health and safety of lifting and transport equipment.

After analysing each sequence of work, the hazard controls carried out in tower crane activities are the substitution method, engineering control, administration, and using PPE. Elimination control could not be carried out because at the time of

observation and research, the tower crane as an object was already operating. Elimination control can be carried out prior to the installation of tower cranes at the project site.

5.5 Discussion

At the Construction Safety Analysis (CSA) Form verification stage, after being corrected, it turns out that there are some data or words that require to be corrected or added. Table 5.6 of the sequence of work contains the additional of word “reinforced concrete” for the installation of tower crane reinforced concrete foundation and additional data for the installation of underframe with reinforced concrete foundation. The addition of this data is due to the fact that during the underframe installation work there were several hazards that could not be combined with the previous work. The hazards that can occur include worker is struck down underframe, worker is trapped underframe, the iron lock is broken, bolt loose and out of control, and the underframe is broken or stuck.

In Table 5.7 there is not many revisions were made. There are additional hazard controls when the operator mobilization to the cabin box by carrying out test and check PJK3 DISNAKER before the tool is operated also OHS checking by PJK3 after the tool is installed. Whereas in the tower crane transports and moves materials work, there is an additional hazard identification for workers, namely worker who working under the tower crane are struck down by materials because the material being transported using tower crane can fall at any time and hit workers who working under the jib traffic area. There are additional hazard controls with using communication tool (HT), code of signs and cues must be clear and understandable, and periodic maintenance of tower crane component because the majority of these components are made of iron and are in open areas, so they are always exposed to sunlight and rainwater.

There are many revision similarities in Table 5.8 with Table 5.6, both word revisions and word additions. In Table 5.8 there is also additional data, it is demolition of reinforced concrete foundation. There are several hazards that can befall workers, equipment, and materials. The hazards are workers hit by jack

drill, the jack drill is broken, materials are struck down by anchor and pieces of concrete. Hazard controls that are carried out by checking equipment, in this case is jack drill, then supervision during the demolition of foundation concrete, and installation the signs to make people know and be careful passing around the working area.

To control potential hazards, substitution control is carried out for the three types of tower crane work namely installation of tower crane, operation of tower crane, and demolition of tower crane. The hazard that can be carried out with this method is technicians and workers are trapped, crushed, and grazed. Another hazard is the equipment fell down and damaged. Control of both types of hazards is carried out by replacing damaged tools and checking wire rope slings periodically.

Engineering control is carried out on the installation, operation, and demolition tower crane with hazards that can be caused is equipment fell down and damaged. Besides that, there is a hazard that materials are fell down, broken, or spilled. Control hazards carried out with using the sling and shackle greater than SF and Installation the crane stands with layer and plates.

Administration control and using PPE are carried out on the installation, operation, and demolition tower crane with hazard that technicians and workers fall from heights or depths and get injured; technicians and workers trapped, struck down, and grazed; equipment fell down and damaged; and materials are fell down, broken, or spilled. Control hazards carried out among them given safety induction, supervision every job, installation the signs, and using PPE.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the results of the research that has been conducted on the lifting and transporting activity using tower crane of Alma Ata University building project with the Construction Safety Analysis (CSA) method is obtained as follows.

1. Identification of potential hazards that have been done using the Construction Safety Analysis (CSA) method obtained 28 types of potential hazards in lifting and transporting activity using tower crane. The most common potential is found in the operation of tower crane as transports and moves materials. As for the most minimum potential hazards found in the activity of operator mobilization to the cabin box in the work of the operation of tower crane and technicians climb the mast towards hydraulic climbing in the demolition of tower crane.
2. Based on the risk control hierarchy, the hazard control measures carried out in this research are substitution, engineering control, administration, and using PPE. While elimination control is not possible.

6.2 Recommendation

Based on the analysis and conclusions obtained after conducting this research, it is known that the occupational health and safety management system (OHSMS) in Alma Ata University building construction project is quite good. As for some recommendations that can be given to construction services providers and further research are:

1. Construction service provider
   a. Procure a construction safety unit as an effort to control and be responsible for implementation of occupational health and safety management system (OHSMS).

b. Increase the knowledge, understanding, and awareness of occupational health and safety in the project by conducting safety induction. This is useful so that workers have the habit of working safely to prevent work accidents.
c. Provide sanctions and strict action to workers, distributors, guests, and all people involved in development who do not implement construction safety.

2. Further research

   Future research can use different subject and/or object with the same or different methods. This is because in this study there may still be deficiencies caused by a lack of thoroughness and detail when making observations. If the subject and/or object is different, it can provide a wider perception of observation.

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APPENDICES

Appendix 1. Figure of The Condition of Alma Ata University Building Construction Project

Figure A-1.1 Tower Crane

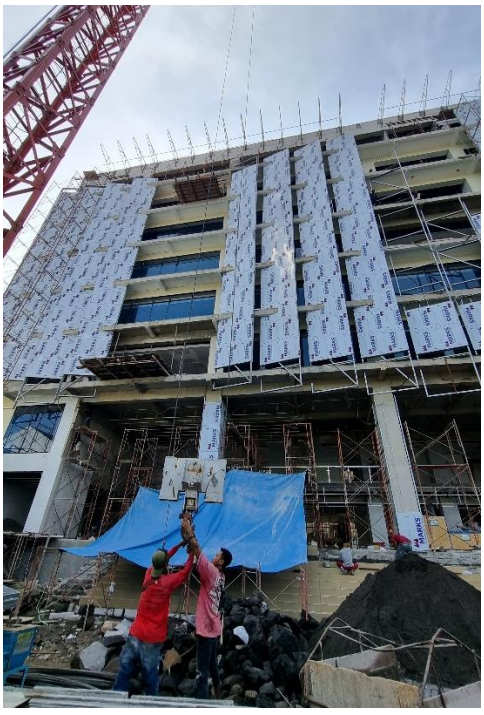


Figure A-1.2 Process of Attaching the Hook to the Material

Figure A-1.3 Installation of Counterweight of Tower Crane

Figure A-1.4 Demolition of Mast Section of Tower Crane

Appendix 2. Construction Safety Analysis (CSA) Form Verification by HSE Expert

Construction Safety Analysis Form

Nama Pemohon Izin kerja : [Nama Pelaksana Pekerjaan]
Pekerjaan : Pemasangan Tower Crane
Tanggal Pekerjaan : DD/MM/YYYY - DD/MM/YYYY*

No : .....
Pengawas Pekerjaan : [Isi Nama Pengawas Pekerja]
Departemen : [Isi Nama Departemen]

Alat Pelindung Diri yang digunakan untuk melaksanakan pekerjaan:

☐ Safety Helmet ☐ Safety Vest ☐ Face Shield ☐ Others .....
☐ Safety Shoes ☐ Full Body Harness ☐ Ear Mufs ☐ Others .....
☐ Safety Gloves ☐ Safety Glasses ☐ Ear Plug
☐ Respiratory ☐ Mask ☐ Appron

No.	Urutan Langkah Pekerjaan	Identifikasi Bahaya				Pengendalian	Penanggung Jawab
		Pekerja	Peralatan	Material	Lingkungan/ Keselamatan Publik		
1	Pemasangan pondasi tower crane Beton Bertulang.	Pekerja terluka karena ~~cangkul~~ (Excavator) Terjatuh dlm Galian	~~Cangkul~~ rusak (Excavator). Terkena kuaci Besi	Terkena tumpahan cor pondasi	-	- Pekerja diberikan informasi keselamatan kerja (safety induction); - Pengecekan alat; - Pengecekan SIO dan SILO ➔ (EXCavator)	Pengawas Pekerja + HSE
2	Pemasangan hydraulic climbing	Pekerja terjatuh dari ketinggian	Sling putus	Hydraulic climbing terjatuh karena terpuntir	Tanah amblas	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pemasangan mast section; - Pemasangan rambu.	Pengawas Pekerja + HSE
3	Pemasangan mast section	Pekerja terjatuh dari ketinggian	Sling putus	Mast section terjatuh karena terpuntir	Tanah amblas	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pemasangan mast section; - Pemasangan rambu.	Pengawas Pekerja + HSE
4	Pemasangan counterweight	Pekerja terjatuh dari ketinggian, Pekerja tertimpa counterweight	Sling putus	Counterweight terjatuh karena terpuntir	Tanah amblas, counterweight menimpa pejalan kaki di sekitar bangunan	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pemasangan mast section; - Pemasangan rambu.	Pengawas Pekerja + HSE

Install rangka bawah dengan pondasi Beton Bertulang

Pekerja tertimpa rangka berbahy. terjepit.

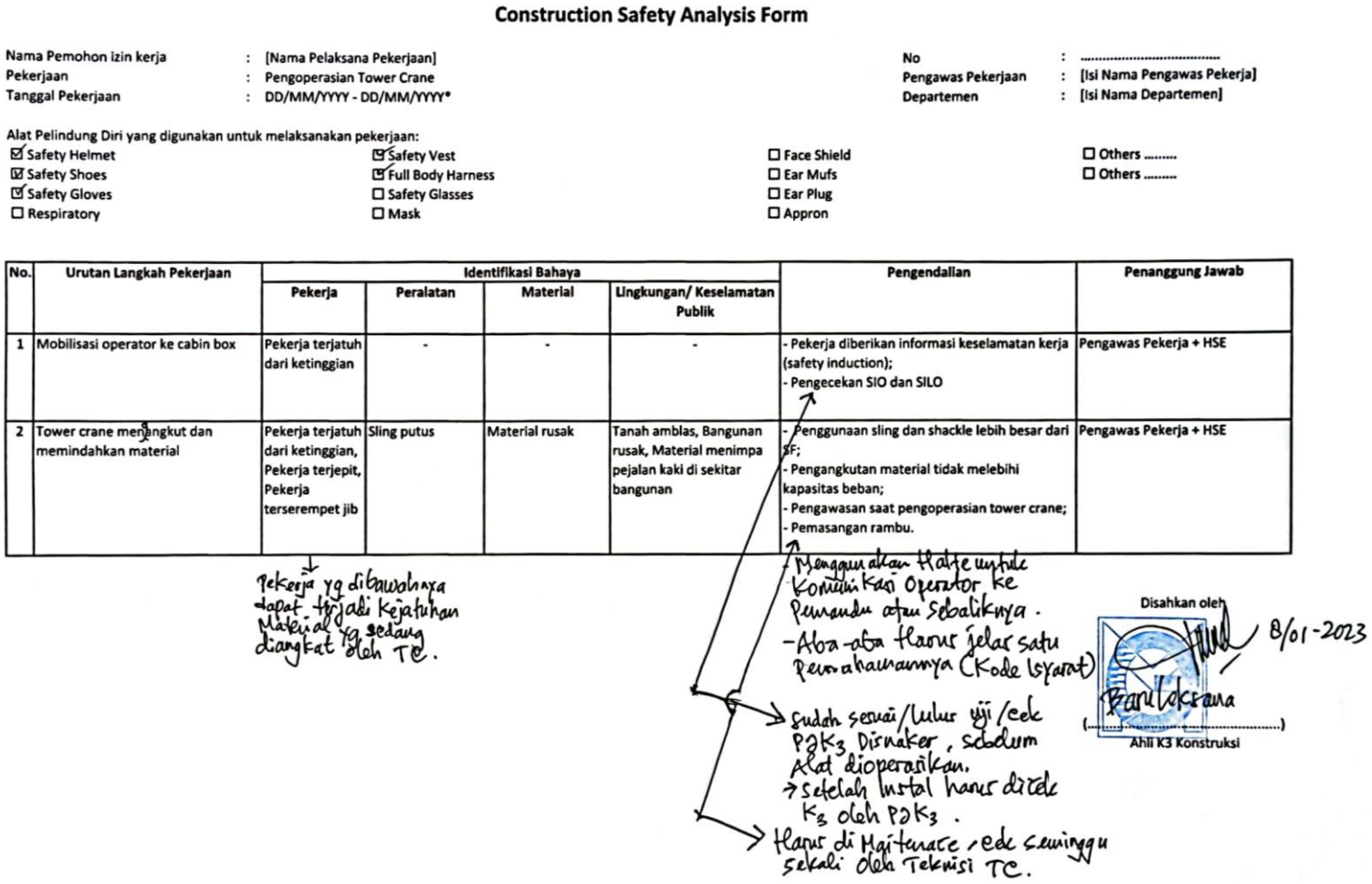
Kuati Baut. Angkur rusak. (terjepit).

-

- Pekerja diberikan Informasi K3. (safety induction)
- Pengecekan Alat.
- Pengecekan SIO & SILO Terkait

5	Pemasangan Jib	Pekerja terjatuh dari ketinggian, Pekerja tertimpa jib	Sling putus	Jib terjatuh karena terpuntir	Tanah amblas, jib menimpa pejalan kaki di sekitar bangunan	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pemasangan mast section; - Pemasangan rambu.	Pengawas Pekerja + HSE

Figure A-2.1 Construction Safety Analysis (CSA) Form of Installation of Tower Crane Verified by HSE Expert



Construction Safety Analysis Form

Nama Pemohon izin kerja : [Nama Pelaksana Pekerjaan]
Pekerjaan : Pengoperasian Tower Crane
Tanggal Pekerjaan : DD/MM/YYYY - DD/MM/YYYY*

No : .....
Pengawas Pekerjaan : [Isi Nama Pengawas Pekerja]
Departemen : [Isi Nama Departemen]

Alat Pelindung Diri yang digunakan untuk melaksanakan pekerjaan:

- ☑ Safety Helmet
- ☑ Safety Shoes
- ☑ Safety Gloves
- ☐ Respiratory
- ☑ Safety Vest
- ☑ Full Body Harness
- ☐ Safety Glasses
- ☐ Mask
- ☐ Face Shield
- ☐ Ear Mufs
- ☐ Ear Plug
- ☐ Appron
- ☐ Others .....
- ☐ Others .....

No.	Urutan Langkah Pekerjaan	Identifikasi Bahaya				Pengendalian	Penanggung Jawab
		Pekerja	Peralatan	Material	Lingkungan/ Keselamatan Publik		
1	Mobilisasi operator ke cabin box	Pekerja terjatuh dari ketinggian	-	-	-	- Pekerja diberikan informasi keselamatan kerja (safety induction); - Pengecekan SIO dan SILO	Pengawas Pekerja + HSE
2	Tower crane mengangkut dan memindahkan material	Pekerja terjatuh dari ketinggian, Pekerja terjepit, Pekerja terserempet jib	Sling putus	Material rusak	Tanah amblas, Bangunan rusak, Material menimpa pejalan kaki di sekitar bangunan	- Penggunaan sling dan shackle lebih besar dari SF; - Pengangkutan material tidak melebihi kapasitas beban; - Pengawasan saat pengoperasian tower crane; - Pemasangan rambu.	Pengawas Pekerja + HSE

Pekerja yg dibawahnya dapat terjadi kejatuhan Material yg sedang diangkat oleh TC.

- Menggunakan Walkie untuk komunikasi Operator ke Pemandu atau sebaliknya.
- Alat-alat harus jelas satu perawatannya (Kode Isyarat)

Sudah sesuai/lulus uji/cek P2K3 Disnaker, sebelum Alat dioperasikan.
→ setelah instal harus dicek K3 oleh P2K3.

Harus di Maintenance/cek seminggu sekali oleh Teknisi TC.

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Pan Loksana
(.....)
Ahli K3 Konstruksi

Figure A-2.2 Construction Safety Analysis (CSA) Form of Operation of Tower Crane Verified by HSE Expert

Construction Safety Analysis Form

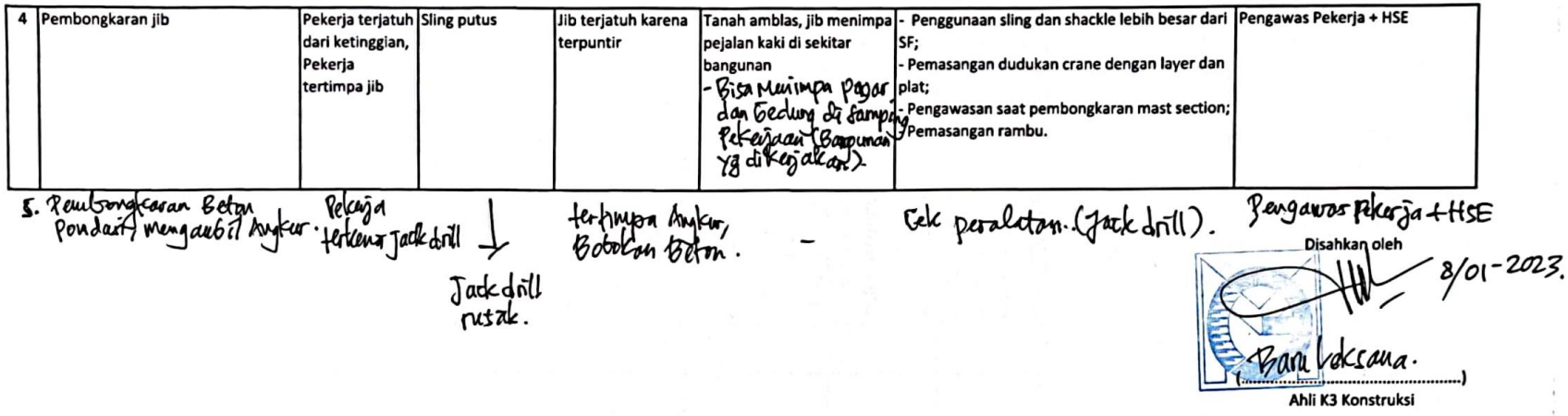
Nama Pemohon izin kerja : [Nama Pelaksana Pekerjaan]
Pekerjaan : Pembongkaran Tower Crane
Tanggal Pekerjaan : DD/MM/YYYY - DD/MM/YYYY*

No : .....
Pengawas Pekerjaan : [Isi Nama Pengawas Pekerja]
Departemen : [Isi Nama Departemen]

Alat Pelindung Diri yang digunakan untuk melaksanakan pekerjaan:

- ☑ Safety Helmet
- ☑ Safety Shoes
- ☑ Safety Gloves
- ☑ Respiratory
- ☑ Safety Vest
- ☑ Full Body Harness
- ☐ Safety Glasses
- ☑ Mask
- ☐ Face Shield
- ☐ Ear Mufs
- ☐ Ear Plug
- ☐ Appron
- ☐ Others .....
- ☐ Others .....

No.	Urutan Langkah Pekerjaan	Identifikasi Bahaya				Pengendalian	Penanggung Jawab
	Tim Tekuisi	Pekerja Tim Tekuisi	Peralatan	Material	Lingkungan/ Keselamatan Publik	(Tim Tekuisi):	
1	~~Operator~~ menaiki mast menuju hydraulic climbing	~~Pekerja~~ terjatuh dari ketinggian (Tim Tekuisi).	-	-	-	- Pekerja diberikan informasi keselamatan kerja (safety induction); - Pengecekan alat; - Pengecekan SIO dan SILO	Pengawas Pekerja + HSE
2	Pembongkaran mast section	Pekerja terjatuh dari ketinggian, Pekerja terjepit	Sling putus Baut lepas - tdk terkontrol	Mast section terjatuh karena terpuntir	Tanah amblas - Menimpa pejalan kaki sekitar area Pekerjaan	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pembongkaran mast section; - Pemasangan rambu. - Menggunakan Alat komunikasi (Hafine).	Pengawas Pekerja + HSE
3	Pembogkaran counterweight	Pekerja terjatuh dari ketinggian, Pekerja tertimpa counterweight	Sling putus Baut terlepas tidk terkontrol	Counterweight terjatuh karena terpuntir	Tanah amblas, counterweight menimpa pejalan kaki di sekitar bangunan	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pembongkaran mast section; - Pemasangan rambu.	Pengawas Pekerja + HSE



4	Pembongkaran jib	Pekerja terjatuh dari ketinggian, Pekerja tertimpa jib	Sling putus	Jib terjatuh karena terpuntir	Tanah amblas, jib menimpa pejalan kaki di sekitar bangunan - Bisa menimpa pagar dan Gedung di samping Pekerjaan (Bangunan yg dikerjakan).	- Penggunaan sling dan shackle lebih besar dari SF; - Pemasangan dudukan crane dengan layer dan plat; - Pengawasan saat pembongkaran mast section; Pemasangan rambu.	Pengawas Pekerja + HSE

5. Pembongkaran Beton Pondasi mengambil Angkur. Pekerja terkena Jackdrill → Jackdrill rusak. terjimpa Angkur, Bobotan Beton. - Cek peralatan. (Jackdrill). Pengawas pekerja + HSE

Disahkan oleh

8/01-2023.

Bara Laksana.

Ahli K3 Konstruksi

Figure A-2.3 Construction Safety Analysis (CSA) Form of Demolition of Tower Crane Verified by HSE Expert