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RISK ANALYSIS WITH THE HIRARC METHOD ON INSTALLATION STEEL BOX GIDER CONSTRUCTION OF ALOHA FLYOVER SIDOARJO

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Abstract:
Research on the Aloha flyover construction project aims to determine the risks that occur in the workmanship of installing steel box girder, knowing the level of risk that occurs in the workmanship of installing steel box girder and knowing how to control the risks that occur in the workmanship of installing steel box girder. The method used in this research is the Hazard Identification Risk Assessment and Risk Control (HIRARC) method guided by the Malaysia HIRARC Guidelines (2008). Starting from identifying hazards at each stage of the work activity, a risk assessment is carried out, the results of which can be used as a reference for risk control, to reduce the risk of work accidents. The results of the analysis from the identification of hazards and risks arising in 5 stages of work and a total of 11 potential hazard findings were obtained. (1) Preparation stage for steel box girder erection maneuver; (2) The process of leveling/compacting the erection area soil for preparation of crawler crane footing/foundation; (3) The process of mobilizing steel box girder material from stockyard to erection area; (4) Installing slings + seals that will be used during steel box girder erection; (5) The process of installing steel box girder using crawler crane. The risk assessment results obtained a total of 11 potential hazard findings with details of 5 potential hazards with a percentage of risk value of 45.54% which is at a high level and 6 potential hazards with a percentage of risk value of 54.55% at a moderate level. The total number of risk level values is 132, with an average value of 12, meaning that the installation of steel box girder is at a moderate level. The results of risk control recommendations after obtaining the risk level value and analyzing the risk value, obtained 6 types of risk control in accordance with the risk control hierarchy, namely elimination, substitution, engineering control, warning system, administrative control, and personal protective equipment (PPE).
Keywords: HIRARC, risk, *steel box girder*

INTRODUCTION

The background to the construction of the Aloha Sidoarjo flyover is the frequent traffic jams around the Aloha area. The Aloha area is one of the congestion points in Sidoarjo, precisely on the west side of the Aloha gas station or beside Maspion from the direction of Surabaya towards Sidoarjo or towards Juanda Airport and vice versa from Sidoarjo towards Surabaya.

This project involves a lot of human resources, namely it is carried out in a limited area, quite large work items, with limited implementation time and an accelerated work completion target due to demands from work stakeholders. Then, the large number of workers and heavy equipment to achieve the target for completing this work will also increase the level of possibility of the risk of work accidents occurring. Apart from that, analysis of the risk of work accidents on this project is quite important to carry out, because the elevated structure has a greater risk of this project passing through highways where traffic jams occur at certain times, passing through active railway lines, densely populated surrounding areas, etc.

Based on the explanation above, reducing the risk of work accidents is very important in a construction project, including the Aloha flyover construction project, especially in the installation of steel box girders. And to reduce the risk of work accidents, potential risks can be identified using the HIRARC (Hazard

Identification, Risk Assessment and Risk Control) method, starting from identifying hazards at each stage of work activity and then carrying out a risk assessment, the results of which can be used as a reference for risk control, so that it can reduce the risk of work accidents.

RESEARCH METHOD

The subjects in this research were workers in the installation of steel box girders and the research object focused on the dangerous risks of installing steel box girders. Primary data collection procedures were obtained from field observations. Observations were carried out to find out and collect data regarding the dangers and risks to workers regarding the process of construction project work activities implementing the installation of steel box girders using HIRARC sheets referring to Minister of Public Works Regulation No. 05 of 2014. Interviews were also conducted with K3 Experts to support the completeness of data collection regarding hazards and risks. Secondary data was obtained from Implementing Contractor data, including implementation RKK documents, Work RMPK documents, work methods/stages for installing steel box girders, and data on work accidents that have occurred during the installation of steel box girders. The research location for the Aloha Surabaya - Sidoarjo flyover construction project is in the Sidoarjo Regency area, East Java Province, which is geographically located at 7.3734°S 112.7258°E.

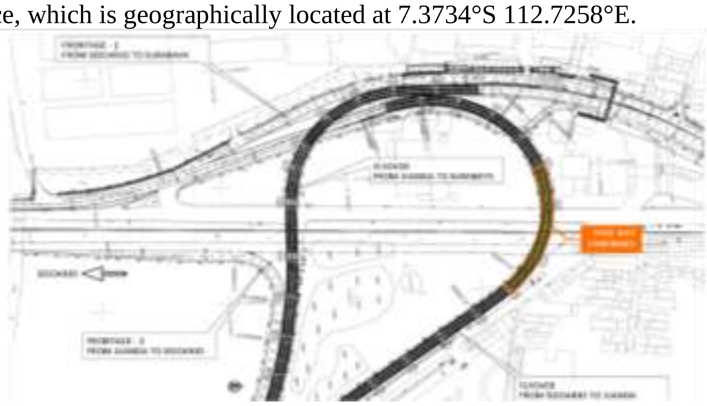

Figure 1. Layout Key Plan of the Research Location

Hazard Identification *(Hazard Identification)*

Hazard identification is the first step in developing K3 risk management. Hazard identification is a systematic effort to identify potential hazards in the work environment. Risk identification is the basis of risk management. Without identifying hazards, it is impossible to manage risks well.

Risk Assessment *(Risk Assessment)*

After identifying hazards, the next stage is risk assessment through risk analysis and evaluation. Risk analysis is intended to determine the magnitude of a risk by considering the possibility of its occurrence and the magnitude of the consequences it may cause. Based on the results of the analysis, it can be determined by grouping and determining the level of risk so that risks can be classified which have a large, medium, small and/or negligible risk impact on the company. The reference used to carry out the risk assessment is in the table below.

Table 1. Qualitative scale of likelihood/frequency (K) based on Malaysia HIRARC Guidelines (2008)

Likelihood/Frequency (K)	Explanation	Value
Most likely (Very Often)	The possibility of danger occurring is very high	5
Possible (Often)	The likelihood of this occurring is high and common	4
Conceivable (Quite Often)	Can happen at any time	3
Remoteb (Rarely)	Never happened for several years	2
Inconceivable (Never)	Impossible/impossible to happen or has never happened before	1

Table 2. Qualitative scale of severity (P) based on Malaysia HIRARC Guidelines (2008)

Severity	Explanation	Value
Catastrophic (Disaster)	There are many deaths, irreversible property damage and lost productivity	5
Fatal (Fatal)	About one death occurred, as well as major property damage	4
Serious (Serious)	Injuries that are not fatal, but cause permanent disability	3
Minor (Minor)	Wounds that are not permanent but cause the sufferer to be unable to do anything	2
Negligible (Ordinary)	Abrasions, bruises, cuts, and other types of first aid wounds	1

The Risk Level (TR) is the result of multiplying the likelihood value/frequency of the risk occurring (K) with the severity/severity value it causes (P). With the following formula:

Risk Level (TR) = K x P ………………………………………………………………………... (1)

The multiplication results of the risk level calculations are explained in Table 3. Risk Matrix as follows:

Table 3. Risk Matrix based on Malaysia HIRARC Guidelines (2008)

	Severity (S)				
Likelihood (L) / Frequency (K)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	13	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Information:

: High K3 Risk Level

: Medium K3 Risk Level

: Low K3 Risk Level

Table 4. Risk Actions based on Malaysia HIRARC Guidelines (2008)

Risk	Description	Action
15-25	HIGH	HIGH risks require immediate action to control the hazard as detailed in the control hierarchy. Actions taken should be documented on the risk assessment form including completion date.
5-12	MEDIUM	MEDIUM risks require a planned approach to controlling the hazard and implementing temporary measures if necessary. Actions taken should be documented on the risk assessment form including completion date.
1-4	LOW	Risks identified as LOW may be considered acceptable and further reduction may not be necessary. However, if risks can be resolved quickly and efficiently, control measures must be implemented and recorded.

After determining the risk level of a job, the next stage is to classify the existing risks from the lowest level to the highest level where the level of job control can be adjusted to the existing risk control.

Risk control *(Risk Control)*

Determining whether the risk can be tolerated or carrying out risk control/risk control (control) for hazards in the work environment are actions taken to minimize or eliminate the risk of work accidents through elimination, substitution, engineering control, warning system, administrative control, personal protective equipment (PPE).

RESULT AND DISCUSSION

HIRARC (Hazard Identification, Risk Assessment and Risk Control)

In this research, the HIRARC method was used to analyze data from each process stage of the work in the construction of the Aloha flyover, especially in the installation of steel box girders. The first step taken is to identify hazards, potential causes of hazards and risks that exist in work activities at each stage of the work process. After knowing the danger, the potential causes of the danger and the risks, a risk assessment is then carried out consisting of a likelihood/frequency assessment (K) and a severity assessment (P) where this assessment score is guided by the Malaysia HIRARC Guidelines (2008) table, and then multiplication will be carried out. between likelihood/frequency (K) and severity assessment (P) to determine the risk level (TR), after knowing the risk level value, the priority scale will be known for taking the next action in the low, medium, or high risk category. This is also guided by from the Malaysia HIRARC Guidelines (2008) table and the last is to carry out risk control by means of elimination, substitution, engineering control, warning system, administrative control, personal protective equipment (PPE) to minimize the risk of work accidents.

a) Hazard Identification, Risk Assessment and Risk Control for Steel Box Girder Installation

In the first stage of the HIRARC method (Hazard Identification Risk Assessment and Risk Control) This carried out identification of hazards, potential causes of danger and risks in the installation of steel box girders for the construction of the Aloha flyover from the initial preparation for steel box girder erection maneuvers to the steel box girder installation process. Identification of hazards and risks is sorted according to the stages of work activities.

After identifying the hazard, the potential causes of the hazard and the risk, the next step is to carry out a risk assessment consisting of a likelihood/frequency assessment and a severity/severity assessment, which will then be assessed by multiplying the likelihood/frequency and severity/severity to determine the level of risk. The next step, after obtaining the value of the risk level and knowing the risk level, is to carry out risk control according to actions that can be taken to minimize the risk of work accidents.

b) Analysis of Hazard Identification, Risk Assessment and Risk Control of Steel Box Girder Installation Process

Based on the analysis of Identification, Assessment and Control of Risks for Installing Steel Box Girders, the results of the observations that have been made, there are 5 stages of the work process for installing steel box girders for the construction of the Aloha flyover using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) method, there are various potential dangers in the process stages of work. The results of the hazard identification that has been carried out are followed by a risk assessment by multiplying the frequency score by the severity score to determine the level of risk using the Malaysia HIRARC Guidelines (2008) table, finally making recommendations/determinations for controlling each risk. The following is an explanation of hazard identification, risk assessment and determination of risk control from the 5 process stages of steel box girder installation work, namely as follows:

1. **Preparation for the steel box girder erection maneuver**

   When preparing to maneuver the steel box material, several tools and materials are needed, such as: *truck flatbed, crawler crane,* and materials *steel box girder*. Responsible for preparations for erection maneuver *steel box girder* this is the K3 Officer and Implementer. Preparatory stage for the erection maneuver *steel box girder* This has dangers and risks, namely:

   a. **The 12 meter long flatbed truck crashed into the water barrier**

      This danger could occur due to opening the water barrier too little because the area is narrow, which can cause material risk *steel box girder* to fall when maneuvering. Risk assessment with a frequency value score of 4 (often), a severity score of 3 (serious), a risk level value of 12 and a priority scale value of 2 is included in the (moderate) category
      Risk controls that can be carried out are as follows:

      - *Engineering Control:*
        - The position of the water barrier that blocks access to flatbed trucks carrying steel box girder material is opened at least according to the length of the flatbed truck, namely 1 meter.
        - Install traffic management and rubber cones in accordance with the work traffic management plan document (RMLL)
        - Installing LED hose lights along the flatbed truck entry access and placing rotary lights at the initial door of the flatbed truck entry access
        - Place the flagman at the steel box girder erection location
        - Ensure that the flatbed truck has a vehicle KIR test and is still valid

- Carry out vehicle inspections and checklists before operating them
- Ensure the driver has an appropriate and valid driver's license.

- *Warning System:* Install an alarm system on a flatbed truck in the form of a distance detector to provide safe distance warnings
- *Administrative Control:*
  - Requires flatbed truck drivers to have a driver's license (driver's license) that matches the type of vehicle and is still valid
    - Requires trucks to have KIR
- PPE (Personal Protective Equipment): Using *safety belt, safety shoes, safety gloves* and vest.

2. **The process of leveling/compacting the ground in the erection area to prepare the footing/base for the crawler crane**

In the process of leveling/compacting the ground in the erection area to prepare the footing/base for the crawler crane, several tools and materials are needed, such as: cylinders and platforms/steel plates. The person responsible for the process of leveling/compacting the ground in the erection area to prepare the footing/base for the crawler crane is the K3 Officer and Executor. This stage of the process of leveling/compacting the ground in the erection area to prepare the footing/base for the crawler crane has dangers and risks, namely:

a. **The crawler crane collapsed and overturned**

This danger could occur due to the condition of the soil being not solid, which creates a risk that when a crawler crane lifts a steel box girder with an unstable foundation, it could cause the steel box girder to fall. Risk assessment with a frequency score of 3 (quite often), a severity score of 5 (disaster), a risk level score of 15 and a priority scale score of 1 is in the (high) category. Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - The ground for the crane's footing/base is mounted on a steel platform/plate before the crawler crane passes over it.
  - Carry out a soil bearing capacity (CBR) test with a value of 6% for basic soil, 95% for compacted soil.
  - Carry out a checklist of the condition of the crawler crane, the crawler crane must have an SIA (equipment permit), have a SILO (operational permit) and the crawler crane operator must have an SIO (operator's permit) who is competent in their field.
- *Administrative Control:*
  - Requires stable soil conditions with a soil bearing capacity (CBR) of 6% for basic soil, 95% for soil compacted by authorized experts
  - Requires a checklist of documents related to crawler cranes starting from SIA (equipment permit), SIO (operator's permit) who is competent in the field, SILO (operating permit), condition and history of the crane and other complete equipment.
- PPE (Personal Protective Equipment): Using *safety belt* and other equipment such as *safety shoes, safety gloves*, helmet, and vest.

3. **The process of mobilizing steel box girder material from the stockyard to the erection area**

In mobilizing steel box girder material from the stockyard to the erection area, several tools and materials are needed, such as: flatbed truck, crawler crane, boogie, and steel box girder material. The person responsible for the process of mobilizing steel box girder material from the stockyard to the erection area is the K3 Officer and Executor. This stage of the steel box girder material mobilization process from the stockyard to the erection area has dangers and risks, namely:

a. **The flatbed truck carrying steel box girders crashed into another vehicle**

This danger can occur because the brakes fail, the operator is incompetent, and the operator is sleepy, which can pose a risk of injury, broken bones, or death. Risk assessment with a frequency score of 3 (quite often), a severity score of 2 (minor), a risk level score of 6 and a priority scale score of 2 is in the (medium) category.

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Carry out traffic lane engineering in accordance with the Work Traffic Management Plan (RMLLP) document.
  - Place the flagman at the steel box girder erection location
  - Carry out vehicle inspections and checklists before operating them

- Ensure that the flatbed truck has a vehicle KIR test and is still valid
- Install LED hose lights on the flatbed truck body and place rotary lights on the flatbed truck head

- *Warning System:* Install an alarm system on a flatbed truck in the form of a distance detector to provide safe distance warnings.
- *Administrative Control:*
  - Coordinate with all personnel involved in steel box girder erection work
  - Requires trucks to have KIR
  - Requires flatbed truck drivers to have a driver's license (driver's license) that matches the type of vehicle and is still valid.
- PPE (Personal Protective Equipment): Using *safety belt* and other equipment such as *safety shoes*, *safety gloves*, helmet, and vest.

4. Install the slings + seals that will be used when erecting the steel box girder

In the stage of installing the slings + seals that will be used when erecting the steel box girder, there are several tools and materials needed such as: crawler crane, boogie, wire rop slings and seals. The person responsible for the stage of installing the slings + seals that will be used during the erection of the steel box girder is the K3 Officer and Executor. The stage of installing the slings + seals that will be used when erecting the steel box girder has dangers and risks, namely:

a. The worker fell from a height while installing and fastening the sling + seal

This danger could occur because workers do not use it *full body harness* thus causing the risk of work accidents. Risk assessment with a frequency value score of 3 (quite often), a severity score of 5 (disaster), a risk level value of 15 and a priority scale value of 1 is included in the (high) category

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Installing *safety net* to protect workers in the event of a fall
  - Make *lifeline* or railing to hook *full body harness* her
  - Ensure workers have a Work at Height Permit and have a certificate of competency to work at height
  - Ensure workers are in good health with a health check before carrying out work
- *Administrative Control:*
  - Conduct a Toolbox meeting (explanation of the dangers of working at heights)
  - Requires workers at height to have a Work at Height Permit and have a certificate of competency to work at height
  - Required to carry out tests and check health conditions before working.
- PPE (Personal Protective Equipment): Use complete PPE starting from *safety shoes*, *safety gloves*, helmet, and vest. Also, wear *full body harness double lanyard with absorber*.

5. The steel box girder installation process uses a crawler crane

In the process of installing steel box girders using a crawler crane, there are several tools and materials needed, such as: crawler crane, boogie, and steel box girder materials. The person responsible for the steel box girder installation process using a crawler crane is the K3 Officer and Executor. This stage of the steel box girder installation process using a crawler crane has dangers and risks, namely:

a. Operators/workers experience fatigue/drowsiness while working

This danger can occur because working hours exceed the limit and lack of rest, which can cause work accidents. Risk assessment with a frequency score of 3 (quite often), a severity score of 4 (fatal), a risk level score of 12 and a priority scale score of 2 is in the (medium) category.

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Ensure workers are in good health with a health check before carrying out work
  - Make a work schedule according to standard working hours a day, if you do overtime, make a work shift schedule
- *Administrative Control:*
  - Requires that there be limits on working hours for workers by creating work shift schedules
  - Required to carry out regular health checks before carrying out work activities
  - Conduct toolbox meetings about existing hazards, as well as emergency response from the contractor before starting work

- Providing a warning sign "CAUTION, DON'T DOWN WHILE WORKING"
- PPE (Personal Protective Equipment): Using *safety belt* and other equipment like *safety shoes, safety gloves*, helmet, and vest.

b. The crawler crane overturned/slipped

This danger can occur because the speed when using a crawler crane is not considered and the condition of the engine, tires or steering system is not checked, which can create a risk of work accidents. Risk assessment with a frequency score of 3 (quite often), a severity score of 2 (minor), a risk level score of 6 and a priority scale score of 2 is in the (medium) category.

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Put up signs "BE CAREFUL MANEUVERING HEAVY EQUIPMENT"
  - Strengthen the base/footing of the crawler crane by ensuring the position of the lifting equipment is stable and installing a platform/iron plate under the crawler crane
  - Make sure the crawler crane level is stable, then check the angle if it is appropriate, read the guideline table for the maximum load capacity that can be carried and the boom angle, if appropriate, do the angle log
- *Administrative Control:*
  - Limit the maximum speed of the crawler crane according to the SOP
  - Requires that crawler cranes must have an SIA (equipment permit) or SILO (operating permit), crawler crane operators must have an SIO (operator's permit) and must be competent in their field
  - Requiring crawler cranes to be checked before use with a checklist of the condition of the engine, tires, steering system, etc.
  - Create a guideline table for the maximum load capacity that can be carried and the boom angle
  - Toolbox meeting about existing dangers, as well as emergency response from the contractor before starting work
  - Ensure the crane is in proper operating condition (passed the mutual test)

c. The crane sling or wire rope broke during the steel box girder erection and hit the worker

This danger could occur because the lifting and transport equipment is not working properly, the condition of the sling is not in good condition or is rusty and the girder is overloaded, and the fastening error can cause the risk of injury, broken bones, or death. Risk assessment with a frequency value score of 2 (rare), a severity value score of 4 (fatal), a risk level value of 8 and a priority scale value of 2 is included in the category (moderate).

Risk controls that can be carried out are as follows:

- *Elimination:* Discard slings that are no longer suitable/standard
- *Substitution:* Sling replaced with a new one
- *Engineering Control:*
  - Ensure that the lifting and transport equipment is suitable for the load of the girder to be lifted
  - Ensure lift and transport aircraft are in operational condition
  - Control slings by cleaning and checking their condition before use
  - Ensure that the sling or wire rope is in a clean, safe/standard condition, by cleaning it and then tagging it that the sling is suitable for use and placed in a place that is suitable for use, separated from slings that are no longer suitable, and this activity is carried out after each use.
  - Isolate the area by putting up signs "DO NOT ENTER DANGEROUS AREA"
- *Administrative Control:*
  - Provide tagging to slings that are ready to be used and provide tagging to slings that are not ready/fit for use, and place them in different places so they don't get mixed up
  - Schedule regular control of the condition of all lift and transport aircraft, including lifting and transport aids by competent operators
  - Conduct a toolbox meeting regarding existing hazards, as well as emergency response from the contractor before starting work
  - Requires crawler crane operators to have an SIO (operator's license) and must be competent in their field.

- PPE (Personal Protective Equipment): Use complete PPE starting from *safety shoes*, *safety gloves*, helmet, and vest.

d. Over swing and the crawler crane overturned

This danger can occur due to roads that have collapsed or are less dense and the operator's skills are limited when operating a crawler crane, which can pose a risk of injury, broken bones, or death. Risk assessment with a frequency score of 2 (rare), a severity score of 3 (serious), a risk level score of 6 and a priority scale score of 2 is in the (moderate) category.
Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Carry out a soil bearing capacity test (CBR) with a value of 6% for basic soil, 95% for compacted soil
  - Monitor wind speed before and during lifting
  - Ensure the tilt angle and boom length comply with the SOP
- *Administrative Control:*
  - Conduct a Toolbox meeting about the correct method before starting a job
  - Carry out safety induction for crawler crane operators, so that they know the dangers that exist, such as points prone to sinking
  - Requires crawler cranes to have a suitable operation permit (SILO)
  - Requires crane operators to have an SIO (operator's license), be able to operate it and have a competency certificate
  - Ensure the crane is in proper operating condition (passed the mutual test)
  - Placement of flagman personnel who are familiar with the work and are always on standby during steel box girder installation operations
  - Placement of clear safety signs "BEWARE OF DIGGING", "DO NOT ENTER DANGEROUS AREAS"
- PPE (Personal Protective Equipment): Use complete PPE starting from *safety shoes*, *safety gloves*, helmet, and vest.

e. Failure in installation due to steel box girder material falling and hitting workers below

This danger could occur due to the operator's lack of skill in carrying out steel box girder installation work, the steel box girder not being firmly attached to the crane sling, lack of bracing reinforcement, and poor bolt stressing results which can cause the risk of injury, broken bones, or death. Risk assessment with a frequency score of 4 (often), a severity score of 5 (disaster), a risk level score of 20 and a priority scale score of 1 is in the (high) category.
Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Installing slippers to support the steel box girder and stiffening the steel box girder using a stiffener
  - Installing steel box girder bracing
  - Providing signs of restrictions on work area operations
  - Create a lifting plan
- *Administrative Control:*
  - Requires crane operators to have an SIO (operator's license), be able to operate it and have a competency certificate
  - Required to issue steel box girder erection work permits and lifting work permits
  - Requiring checking the condition of the crawler crane for proper operation (passing the mutual test)
  - Toolbox meeting about existing dangers, as well as emergency response from the contractor before starting work
  - Install warning signs "BEWARE OF GIRDER ERECTION WORK"
  - Isolate the area by putting up signs "DO NOT ENTER DANGEROUS AREA"
- PPE (Personal Protective Equipment): Use complete PPE starting from *safety shoes*, *safety gloves*, helmet, and vest.

f. Installation process of steel box girder using crawler crane

This danger could occur due to the lack of firmness of the ground/track of the crane, so that it is not able to withstand the load of the crane itself, thus causing the risk of injury, broken bones, or death.

Risk assessment with a frequency value score of 4 (frequent), a severity value score of 4 (fatal), a risk level value of 16 and a priority scale value of 1 in the (high) category

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Ensure the footing/foundation for the crawler crane is stable by providing a platform/iron plate under the crawler crane
  - Carry out a soil bearing capacity (CBR) test with a value of 6% for basic soil, 95% for compacted soil.
  - Ensure that the steel box girder material load does not exceed the maximum lifting load of the crawler crane
- *Administrative Control:*
  - Perform checklist inspection of steel box girder erection
  - Requiring all heavy equipment operators to hold a toolbox meeting regarding good and correct work methods before starting work
  - Requires crawler cranes to have a suitable operating permit (SILO) and are in good operating condition
  - Requiring crane operators to have an SIO (operator's license), ensuring the operator can operate it and has a competency certificate
  - Carry out safety induction about existing dangers, as well as emergency response
- PPE (Personal Protective Equipment): Using *safety belt* Complete PPE starting from *safety shoes, safety gloves*, helmet, and vest.

g. Worker falls from height

This danger could happen because the health and mental condition of the workers is not good and the condition of the work floor is not strong and unsafe so that it is not able to withstand the load of the crane itself, thus causing the risk of injury, broken bones, or death. Risk assessment with a frequency value score of 4 (frequent), a severity value score of 4 (fatal), a risk level value of 16 and a priority scale value of 1 in the (high) category

Risk controls that can be carried out are as follows:

- *Engineering Control:*
  - Use *full body harness double lanyard with absorber*.
  - Installing a safety net to protect workers when they fall.
  - Make a lifeline or railing to attach the full body harness
  - Ensure workers have a Work at Height Permit and have a certificate of competency to work at height
  - Ensure workers are in good health with a health check before carrying out work
- *Administrative Control:*
  - Required to carry out regular health checks/health and mental checks before carrying out work activities
  - Requires workers at height to have a Work at Height Permit and have a certificate of competency to work at height
  - Requiring a toolbox meeting regarding existing hazards and emergency response from the contractor before starting work
- PPE (Personal Protective Equipment): Use complete PPE starting from *safety shoes, safety gloves*, helmet, and vest. Also, wear *full body harness double lanyard with absorber.*

c) Summary of Analysis of Hazard Identification, Risk Assessment of Steel Box Girder Installation

From the overall analysis that has been carried out, there are 5 process stages for the work of installing steel box girders for the construction of the Aloha flyover using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) method. A summary of the hazard identification and risk assessment can be seen.

The results of the analysis show that in recapping the hazard identification and risk assessment of the 5 process stages of work, there are 5 hazards that fall into the high risk level category, namely the danger of the crawler crane collapsing and overturning, workers falling from a height during installation and fastening of slings + seals, failure in installation due to The steel box girder material fell and hit the worker below, the crawler crane collapsed during the steel box girder erection and the worker fell from a height. Then there are 6 dangers that fall into the medium risk level category, namely danger the 12 meter long flatbed truck hit the water barrier, the flatbed truck carrying the steel box girder hit another vehicle, the operator/worker experienced fatigue/drowsiness while working, the crawler crane rolled/slipped, the crane sling or wire rope broke during the erection of the steel box girder and hit the worker, and over swing and finally the crawler crane rolls over. From 5 work stage process the total danger and risk of installing steel box girders is 11 activities, and the total number of risk level values is 132, with an average value of 12, meaning that installing steel box girders is at a medium level.

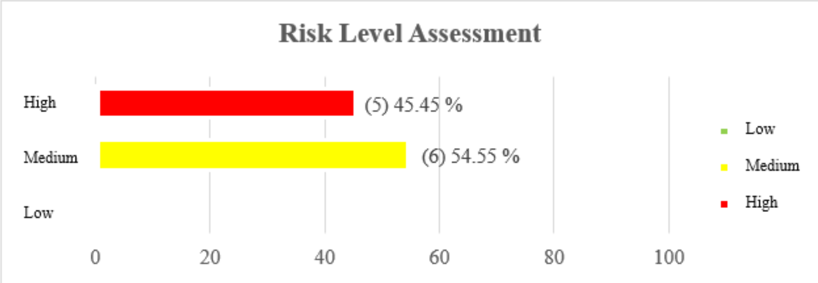

Figure 2. Percentage of Risk Value in Installing Steel Box Girder

In Figure 2 above is the percentage risk value for steel box girder installation work with a total of 11 potential hazards. There are 5 potential hazards with a risk value percentage of 45.54% which are at a high level and 6 potential hazards with a risk value percentage of 54. 55% which is at the medium level.

CONCLUSION

1. The results of the analysis of the identification of hazards and risks that arise in 5 stages of work and a total of 11 potential hazard findings were obtained. (1) In the Preparation Stage for the steel box girder erection maneuver, the potential danger of a 12 meter long flatbed truck hitting a water barrier was found; (2) The process of leveling/compacting the ground in the erection area to prepare the footing/base for the crawler crane reveals the potential danger of the crawler crane collapsing and overturning; (3) The process of mobilizing steel box girder material from the stockyard to the erection area revealed the potential danger of the flatbed truck carrying the steel box girder crashing into another vehicle; (4) Installing the slings + seals that will be used when erecting the steel box girder, there is a potential danger of workers falling from a height when installing and fastening the slings + seals; (5) In the process of installing steel box girders using a crawler crane, there is a potential danger of operators/workers experiencing fatigue/drowsiness while working, crawler cranes toppling/slipping, crane slings or wire ropes breaking during steel box girder erection and hitting workers, over swinging and crawler cranes overturned, installation failure due to steel box girder material falling and hitting workers below, crane collapsing during erection of steel box girder and workers falling from a height.
2. The results of the analysis from assessing the risk level and priority scale for 5 stages of work, a total of 11 potential hazard findings were obtained, with details of 5 potential hazards with a risk value percentage of 45.54% which was at a high level and 6 potential hazards with a risk value percentage of 54. 55 %. The total number of risk level values is 132, with an average value of 12, meaning that the steel box girder installation is at a medium level.
3. The results of the risk control recommendations after obtaining the risk level values and analyzing the risk values, obtained 6 types of risk control in accordance with the risk control hierarchy, namely elimination, substitution, engineering control, warning system, administrative control, and personal protective equipment (PPE).

Suggestion

Suggestions that the author can give for the steel box girder installation work for the Aloha flyover construction project are as follows:

1. Future researchers are expected to be able to analyze work related accident trends, namely Frequency Rate (FR) Analysis, Safety Rate (SR) Analysis and Safe T Score Analysis.
2. It is recommended that further researchers carry out thorough observations and analysis of hazards and risks at other work stages to achieve zero accidents.
3. For practitioners in installing steel box girders which have a high risk level, control is done by means of engineering control, administrative control, and PPE (personal protective equipment).
4. Installation of steel box girders should not be carried out in bad weather or not after rain, because there are many potential dangers considering the environmental conditions and soil in the form of embankments.

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