Design improvement for safety risks using hazard and operability method

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Abstract. Application of occupational health and safety procedures consists of programs that aim to protect and welfare the workers. However, in reality, many workers still carry out such violations related to work procedures. This study aims to determine the risk of breaches that affect the procedure works and know the dominant risk affecting workers on the World Trade Centre (WTC) -3, Jakarta. This research approach uses the HAZOP method and SPSS to analyze the validity and reliability of data. The methods used to identify risks are brainstorming or interviews with the experts and operability study (HAZOP). From these results obtained on 14 sources from 23 sources of work activities with a high-risk level, which is the dominant risk, it should get priority to be fixed or controlled to minimize accidents at the height of the World Trade Centre (WTC) -3, Jakarta.

1. Introduction

According to the international labor organization (ILO), around the world estimates that some 60,000 fatal accidents in construction occur each year. Those who work in the construction industry do not have access to seek training to repair or steps K3. Accidents in construction projects are falling from heights, hit by falling objects, machinery, electricity, and extracting [1].

When performing an activity in project development, especially jobs at altitude, issues are occupational health and safety factors. It happened in the World Trade Centre (WTC) project -3 Jakarta, located on Jl. Jend. Sudirman Kav.29, Kel. Karet, district. Setia Budi - south Jakarta. In any event always involves human project location, equipment, and interaction with nature. This work contains risks for each element involved. Therefore, occupational safety and health (K3) should get the most attention to minimize the risk of occupational accidents.

Figure 1. Site Plan
Source: World Trade Centre (WTC) project -3 Jakarta, 2017
In anticipation of all these things in the World Trade Centre (WTC) project -3, Jakarta has been running a work permit. The completeness of equipment personal protective in work permits, especially relating to work altitude, although such work accidents still occur. Infringement procedures work in the World Trade Centre (WTC) -3 Jakarta project, increasing between 2016 and 2017 at 4.5%. In 2016 recorded data on violations of 68 violations, while in 2017, a rise of 75 offenses. We can see that many violations occurred from the data even though in the World Trade Centre (WTC) project -3 Jakarta is already running a procedure that works mainly on altitude. It is necessary to analyze operating procedures on the World Trade Centre (WTC)-3 project, Jakarta.

2. Theoretical framework
To analyze the safety and health risks in this study using hazard and operability studies (HAZOP), the authors conducted a review of data collection directly to the project site and interviews with the parties involved. Here are the steps to perform the collection and identification of hazard:
1. Specifies the sequence of processes that exist in the study area.
2. We are identifying hazards found in the study area.
3. Complementing the existing criteria in the HAZOP worksheet in the following order:
   a. Classify the found hazard (hazard source and hazard finding frequency)
   b. Describe the deviation that occurs during a surgical procedure.
   c. Describe the causes of the deviation (reason).
   d. Describe what may result from these deviations (Consequences).
   e. It is determining action or temporary measures that can do.
   f. Assessing risk is embossed with the criteria defining likelihood and consequence (severity) criteria of likelihood and consequences (Table 1 and Table 2).

| Table 1. Frequency scale (Likelihood) [2]. |
|------------------------------------------|
| Level | Level Frequency | Description                                           |
|-------|-----------------|-------------------------------------------------------|
| 1     | Might happen    | Possible danger                                        |
| 2     | Almost occur    | The probable danger in certain circumstances (in exceptional circumstances) |
| 3     | Sometimes       | There may be little danger or coincidental             |
| 4     | Rarely          | It cannot happen, but the possibility remains          |
| 5     | Frequent        | chance of a hazard under certain conditions            |

| Table 2. Scale consequences (severity) [3]. |
|--------------------------------------------|
| Level | Level Frequency | Description                                                                 |
|-------|-----------------|-----------------------------------------------------------------------------|
| 1     | Very little     | the incident did not cause injury to a human.                               |
| 2     | Small           | They are potential minor injuries, minor damages, and no serious consequences.|
| 3     | Moderate        | severe injuries and were hospitalized, not cause permanent disability, average financial loss. |
| 4     | Weight          | It causes severe injuries and permanent disabilities, and significant financial losses and has a severe impact on business continuity |
| 5     | Disaster        | Causes severe casualties and losses can even suspend operations indefinitely. |
g. Perform a hazard level identified using the worksheet hazop by taking into account likelihood and consequence, then using the risk matrix (figure 1) to determine the priority hazard that should give priority for improvement.

![Figure 2. Risk matrix [3]](image)

h. Designing improvements to the risk with a level of "extreme" and then making recommendations for improvement.

3. Research method

This study consisted of data collection of primary data and secondary data. Preliminary data uses interviews and questionnaires to the respondents and parties involved in the World Trade Center (WTC) project -3, Jakarta. Respondents in this study were the staff and the workers involved in the World Trade Centre (WTC) project -3, Jakarta.

Table 3. Research Gap literature or journals associated with this research

| Article | Occupational Health and Safety Management System | Risk Assessment | Work at height | OHSAS HIRARC | FTA | HAZOP | SPSS | AS/NZS | Construction Project |
|---------|-----------------------------------------------|-----------------|----------------|--------------|-----|-------|-----|--------|---------------------|
| [1]     | √                                             | √               | √              | √            |     |       |     |        |                     |
| [4]     | √                                             |                 | √              | √            |     |       |     |        |                     |
| [5]     | √                                             | √               | √              | √            |     |       |     |        |                     |
| [7]     | √                                             | √               | √              | √            |     |       |     |        |                     |
| [8]     | √                                             |                 | √              | √            |     |       |     |        |                     |
| [9]     | √                                             |                 |                |              |     |       |     |        |                     |
| [10]    | √                                             | √               |                |              |     |       |     |        |                     |
| [11]    | √                                             |                 |                |              |     |       |     |        |                     |
| [12]    | √                                             |                 |                |              |     |       |     |        |                     |
| This research | √                                             |                 |                |              |     |       |     |        |                     |
From each respondent to provide information relating to the research conducted, according to the area they control on the position of the respondent in the construction phase in the project of the World Trade Centre (WTC) -3, Jakarta. The primary data obtained through interviews and the questionnaire are the data associated with respondents' risk profile and the appropriate or relevant in the World Trade Center (WTC) project -3, Jakarta at the stage of construction. At the secondary data collection stage, by collecting references as a reference in this study of literature or journals associated with this research.

4. Result and Discussion

The sample is part of this population's number and characteristics [4]. The population in this study is 25 people with the position staff engineering and staff HSE, and then to determine the sample size used formula slovin by the following equation.

\[
    n = \frac{N}{N(e)^2 + 1}
\]

With the caption:
- \( n \) = Number of samples / respondents
- \( N \) = Number of population
- \( e \) = Percentage error tolerated

The total of the number of respondents amounted to 25 people, for the percentage of error tolerated taken 10% then found the number of respondents as follows.

\[
    n = \frac{25}{25(0.1)^2 + 1} = 20 \text{ respondent}
\]

To determine the degree of risk (risk level), taking into account risk criteria as follows:
- Likelihood (L) is the scale of the frequency of risk occurrence with procedures for working at height criteria (possibility shown in Table 1).
- The scale of the consequences or Consequences (C) is a measurement of the level of impact (impact) the risk of procedures for working at height (we can see scale consequences in Table 2).

After determining the values of likelihood and consequences of each variable, the next step is to multiply the value of probability and effects that will get the value danger or hazard level on the risk matrix (Figure 1), which will use to perform rank to sources of hazard conducted on improvement. Levels of risk / HAZOP worksheet that is determined based on the criteria of likelihood and consequences. Furthermore, the design of recommendations or proposed improvements based on the potential hazards that occur. The proposed revision of control is based on expert advice to minimize or not implement the risk. For improvement, recommendations for the hazard source with a value of ranking the highest risk. With the proposed revisions, the company expected to reduce or minimize the level of accidents and prevent similar accidents, particularly those relating to work at height.

Table 4 results from the dominant control or risk management analysis based on expert advice to minimize the risk of harm in doing work at heights. The results of mapping determining the risk level of the total bet are as Figure 3.
### Table 4. Risk Control of Improvement design for safety risks

| Working at Height procedures | Subprocess of Work activity | Risk of Occurrence | Cause | Risk Level | Risk control |
|-----------------------------|-----------------------------|--------------------|-------|------------|--------------|
| Personal Fall Protection Systems | Harness | sure each worker will work in the area have been using the harness heights. | - Incorrect use  
- One type of harness  
- Workers did not use  
- point anchorage harness incompatible  
- Do not use a harness | Workers have not been trained  
Errors identified needs work  
yet in training or no signs  
Harness unavailable or damaged | High risk | - Ensure procedures / IK work at altitudes and applicable.  
- Do training work at altitude  
- Assessment training works at altitude |
| Ensure harness to use in good condition. | - the condition of brittle  
- Conditions broken  
- Rupture in harness  
- harness broken remains in use | - not inspected  
- Incorrect storage  
- Harness is not worth wearing  
- Lack of knowledge | High risk | - Appoints competent personnel responsible for harness inspection  
- Imposing sanctions for violation of the provisions of the harness. |
| Lanyards | Ensure harness which the workers have used functioned adequately. | - Failed function  
- Leopard straps  
- Webbing not associated with Buckle | - Usage is incorrect  
- Harness is not routinely checked | High risk | - Conduct work inspections, including working at altitude.  
- Practice proper harnessing in the TBT forum or prestart briefing. |
| Ensuring hook lanyard is not directly connected to the static line | - Layard broke up  
- The hook diameter does not match the anchor point  
- The location of the fox harrows | - Material with low quality  
- Not enough knowledge  
- Static line not available | High risk | - Applying standard quality harness at the time of purchase.  
- Specifies an alternative static point for hook lanyard link. (recorded in IK / working procedure) |
| Using the Personal Fall Protection System | Keep the harness and waistband in a suitable place so as not to damage the harness and waist. | - Material or porous damage  
- Exposure to chemicals  
- Grow mushrooms on webbing hames | - Eyed gravel or sharp objects  
- Lack of knowledge  
- A humid place | High risk | - Attach signs information Harmon storage procedures.  
- Allocate a special place for harbor storage. |
| Detaching and Re-Attaching Belts and Harnesses at Height | Ensure the second rope should still use by the worker. | - Slipping on move position because there is no safety  
- Layard broke up  
- Not using two straps | - Not connected second layer  
- Unable to withstand burden and no inspection  
- Unavailability of double ropes | High risk | - Training work at altitude  
- Calculation of maximum load engineering is using withheld. |
| Working at Height procedures | Work activity | Risk of Occurrence | Cause | Risk Level | Risk control |
|-----------------------------|--------------|--------------------|-------|-----------|--------------|
| Always be careful and still ensure the lanyard is not twisting up when not in use. | - Triple the rope - Layard twisted - The double lanyard procedure is not implemented | - Rope not positioned properly - No maintenance - Lack of knowledge | High risk | - Training work at altitude - Workplace inspection/working methods for work at height. |
| Tools and Equipment | Make sure the tool used is not corrupt. | - Defective tools are still in use - Wrapped material - The instrument used is broken | Inspection was not perform - APD material is not standard - No periodic inspections are performed | High risk | - Create procedures / IK inspection harnes, communicated, and conducted training. - Appoint personnel to handle Harley inspections. |
| Training | Works at altitude and use of personal protective equipment (Harness, helmet, safety shoes). | - Workers do not understand the risks - Fall, bump - Workers do not use APD | Training is not appropriate - Not following procedures and APD is not used - APD unavailable or damaged | High risk | - Communicate the stages of work, the danger, and the risks. - Preparing adequate APD as needed. |
| Emergency response procedures. | - Team does not understand - Procedure not understood - The dangers that occur can be maximized | - Not well socialized - Absence of socialization - Lack of knowledge | High risk | - It ensured that emergency procedures exist and are applicable. - Communication of emergency procedures to the personnel involved. - To socialize about K3 to the workers. - Imposes sanctions for violations of the rules. |
| Occupational Safety and Health Regulations (K3) on work at altitude | - Workers disobey - Rules are not followed as well as many violations - Workers do not know the rules of working at altitude | - Lack of management impetus and lack of socialization - No fines - Less socialization about regulation works at altitude | High risk | - Training of equipment inspection procedures. - Conduct periodic audit results of the inspection. |
| Inspections | We are ensuring that activities according to standards. | - No personnel concerned or ensure - The work is unsafe - The procedure does not run | - There is no clear roller and responsibility designation - Absence of inspection - Socialization of systems is not a communication to workers | High risk | - Training work at altitude - Workplace inspection/working methods for work at height. |

Source: Processed Data Writer, 2017
Based on Figure 3 can be seen, there are 14 (fourteen) risks that have a high risk who are in the red, while the chances are on the blue number 8 (eight), and the low risk there is 1 (one) who are in yellow.

5. Conclusion
From the results of risk analysis, there are 23 risks of 8 work activities:

a. General measures of prevention fall 3 (three) risks of the violation.
b. Personal protection system falls 4 (four) risk violations
c. Using the personal protection system falls 4 (four) violation risk
d. Detaching and Re-Attaching Belts and Harnesses at Height 2 (two) violation risk
e. Tools and Equipment 2 (two) violation risk
f. Training 3 (three) violation risk.
g. Inspections 3 (three) violation risk.
h. Safety harnes register 2 (two) violation risk.

From each activity, there is a sub-activity or work activity. Each work activity is analyzed as the most dominant risk or high risk to do planning for Improvement design for safety risks using hazard and operability method.

For improvement, recommendations for the hazard source with a value of ranking the highest risk. There are 14 dominant risks from 23. With the proposed revisions, the company expected to reduce or minimize accidents and prevent similar accidents, particularly those relating to work at height based on the experts' recommendation.

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