:: IJEBD ::
(International Journal of Entrepreneurship and Business Development)
Volume 07 Number 02 March 2024

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Work Accident Risk Analysis in Tukad Ayung Bridge Replacement Project

Ida Bagus Made Yatana, Putu Ika Wahyuni, I Wayan Muka
Infrastructure and Environmental Engineering Master's Study Program, Postgraduate
Warmadewa University, Indonesia
Corresponding Author*: ibyatana99@gmail.com

ABSTRACT

Purpose: Analysis of the risk of work accidents in the Tukad Ayung Bridge replacement project needs to be carried out by identifying, assessing, and controlling risks using the HIRARC method. This study aims to conduct a work accident risk analysis in the Tukad Ayung Bridge replacement project, precisely in the implementation of concrete girder installation.

Design/methodology/approach: The data used are qualitative and quantitative data with primary data sources and secondary data. The data collection techniques used are observation, interviews, questionnaires, literature studies, and documentation studies. The data analysis technique used is HIRARC.

Findings: The results showed that; 1) There are 24 types of work accident risks identified in the concrete girder installation work in the Tukad Ayung bridge replacement project in seven stages of work, namely, the concrete girder preparation stage, girder truss making, erection (segmental girder setting), prestressed steel installation (strand), strand cable stressing work, girder concrete tendon grouting, and diaphragm installation stage, 2) The results of risk analysis on concrete girder installation work on the project The replacement of the Tukad Ayung Bridge, is in the moderate category, which is as many as 12 risks with a percentage of 50%. Furthermore, as many as 11 risks are included in the high category with a percentage of 45.837%. Meanwhile, in the extreme category as much as one risk with a percentage of 4.17%, 3) Risk control efforts that can be carried out from the three levels of risk found, namely moderate, high, and extreme, namely by reducing risk through administrative control, engineering control, and warning system.

Paper type: Research paper

Keyword: *Risk Analysis, Work Accident, Tukad Ayung Bridge.*

Received : November 4th
Revised : February 18th
Published : March 31th

I. INTRODUCTION

The rapid growth and economic development that results in increasing population needs requires adequate transportation facilities and infrastructure in quality and quantity. In this regard, on the Simpang Cokroaminoto - Simpang Tohpati road there are three steel frame bridges that have a pavement width of 7 meters (two lanes) while the width of the road pavement is 14 meters (four lanes, two lanes). This causes a narrowing of the road when passing the three bridges. Therefore, a bridge replacement project was carried out Simpang Cokroaminoto - Simpang Tohpati so that traffic flow could be launched.

One of the bridge replacement projects on the Simpang Cokroaminoto - Simpang Tohpati bridge section is the replacement of the Tukad Ayung Bridge. The Tukad Ayung Bridge replacement project is one of the important aspects in efforts to improve infrastructure in Denpasar City, especially in East Denpasar district.

Tukad Ayung Bridge is one of the bridges that underwent replacement which aims to improve bridge infrastructure. This project is also carried out to improve inter-regional connectivity in addition to providing alternatives for residents to increase economic productivity. Tukad Ayung Bridge was previously an Australian

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

type steel truss bridge that had a pavement width of 7 meters (2 lanes). After replacement, the bridge is currently a concrete girder construction type so that its service life is stronger and more durable.

Considering that the Tukad Ayung bridge is the only access that connects between regions on the Simpang Cokroaminoto - Simpang Tohpati bridge, of course, this bridge replacement project is very important to do. In addition to the importance of the role of the bridge, it is also important to identify possible risks that arise in the Tukad Ayung bridge replacement project. Many risks may occur, both as a result of high rainfall causing flooding, water runoff that can wash away passing motorists, to the risk of work accidents that can be experienced by project workers. In this regard, this study reviewed the risk of work accidents in the Tukad Ayung Bridge replacement project, especially in concrete girder installation work.

Safety issues are also part of project planning and management. The implementation of Work Health and Accidents (K3) in the workplace aims to create a safe, comfortable, and healthy working atmosphere and environment for workers (Nursyachbani &; Susanto, 2018). The construction industry is considered the most vulnerable to accidents, the causes that often occur work accidents are human error, electric shock, and falling from a height (Soekiswara, 2020).

Research conducted by Wiyasa et al., (2015) showed that 78 high risks were identified, the most of which were in Tower Crane Operation work items. To reduce risks in the implementation of construction, it is necessary to carry out training related to K3 risks to each worker, implement a shift system and provide holidays to workers alternately, conduct health checks, control hazardous and high-risk work environments. In addition, research conducted by Novi & Apdeni (2022) which aims to determine the level of risk of work accidents in the construction project of replacing the Titian Panjang-Kayu Tanam bridge in West Sumatra, shows that as many as 8 work items were identified with the hazard identification, risk and opportunity assessment (IBPRP) method, the results of the work accident risk level values were as follows: 44% major risk, 56% medium risk, and 0% low risk.

Suparman & Fitriani (2016) also conducted a work accident risk analysis on the Musi VI Bridge project in Palembang, where this study showed that there were 64 risks of occupational injuries with 13 low risks, 47 medium risks, and 4 high risks. This risk control effort is carried out by requiring workers to use PPE according to the type of work, strict supervision of workers in the use of PPE, checking the work environment (safety patrol) regularly, safety talk every week, installing safety signs and checking worker health.

Based on the description above and previous research, this study has differences with research conducted by Wiyasa et al., (2015), Novi &Apdeni (2022), Suparman &; Fitriani (2016), which specifically analyzes the level of hazard risk in the implementation of Concrete Girder installation using the Hazard Identification, Risk Assessment And Risk Control method(HIRACH). Based on initial observations, in the Tukad Ayung bridge replacement project there are several causes of work accidents, such as workers who do not use complete Personal Protective Equipment (PPE), heavy rain so that work stops, activities side by side with heavy equipment and others so it is necessary to conduct research on work accident risk analysis in the Tukad Ayung bridge replacement project.

A. Literature Review

a. Occupational Health and Safety (K3)

Occupational Safety and Health (K3) philosophizes as a thought and effort to ensure the integrity and perfection of physical and spiritual work in particular and humans in general, the results of their work and culture towards a prosperous and prosperous society. While scientific understanding is science and its application to prevent the possibility of accidents and occupational diseases (Nursyachbani &; Susanto, 2018). Part of the company's overall management system which includes organizational structure, planning, implementation, responsibilities, procedures, processes and resources needed for the development, implementation, achievement, review and maintenance of occupational safety and health policies in order to control risks related to work activities in order to create a safe, efficient and productive workplace (International Labour Organization, 2013).

b. Occupational Health and Safety Risks (K3)

K3 risk is a risk related to the source of hazards arising in various activities that concern aspects of people, equipment, materials, and the work environment. Generally, risk is connoted as a negative thing (negative impact). Losses due to accidents from other events are risks that must be faced by every organization or company. To deal with the risks associated with K3, various concepts and approaches have developed to prevent accidents and unwanted events. One of the efforts to control K3 is to implement an Occupational Health and Safety Management System (SMK3) (Setiyadi, 2012).

c. Risk Management

Risk management is a process of identifying, measuring risks and establishing a strategy to prevent and deal with risks. Risk management is an integral part of the management process that runs within a company or institution. Risk management involves the process, culture, and structure in managing a risk effectively and planned in a good management system (Ramli, 2010). In the K3 aspect, risk management is an effort to manage

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

K3 risks to prevent unwanted accidents in a planned manner, and structured in a good system. K3 risk management relates to hazards and risks that exist in the workplace where these hazards and risks can cause losses to the company and workers. Based on some of these explanations, the concept of Risk management can be compiled as a form of management of Risk to minimize adverse consequences that may arise through planning, identification, analysis, handling, and monitoring of Risks. Risk management is defined as the process of identifying, measuring, and ascertaining risks and developing strategies to manage those risks. In this case, risk management will involve processes, methods, and techniques that help project managers maximize the probability and consequences of positive events and minimize the probabilities and consequences of opposite events (Socrates, 2013).

d. Concrete Girder

In the world of construction, the meaning of concrete girder is a concrete block that is between two supports which can be pear or *abutment* in bridge construction. The function of the concrete girder beam is to channel the load above the construction to be delivered to the structure at the bottom. In general, the girder can be in the form of steel beams in the form of profile I, in the form of concrete blocks in the form of I (*Prestressed Concrette I Girder / PCI Girder*), some are in the form of boxes or boxes (often referred to as *box girders*), some are T-shaped and also several other shapes. Concrete girder has a span length from 20 meters to 40 meters so it is often used in bridge construction.

According to the design system, concrete girder is a girder that can be divided into two, namely precast concrete girder and also on-site concrete girder. Precast girder concrete is a concrete girder that has been produced and molded at the factory and then transported to the project site or field where the girder concrete will be used. While on-site girder is a concrete girder that is cast in the field or at the place of project implementation. This on-site girder can be a custom girder or a girder designed according to the model and follows the concrete design process in general, which uses formwork as a form of mold.

II. METHODS

This research was conducted on the Tukad Ayung bridge replacement project precisely located on Jalan Gatot Subroto Timur, Denpasar. The location of Tukad Ayung Bridge is at coordinates: 8038'09.86" S 115014'21.12" E. The types of data used in this study are quantitative and qualitative data. The data sources used are primary data sources and secondary data. The population in this study is project managers, supervisors, and technical experts who are outside the Tukad Ayung Bridge replacement project totaling 42 people. Based on calculations using the Slovin formula, the sample in this study was obtained as many as 30 respondents. The data collection methods used in this study were observation, interviews, doocumentation studies, literature studies, and questionnaires using a Likert scale of 1-5. The data analysis technique used in this study is HIRARC.

Figure 1. Research Location

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

III. RESULTS AND DISCUSSION

A. Characteristics of Respondents

The characteristics of respondents indicate the identity of the respondents used in this study. The characteristics of respondents in this study can be seen in Table 1.

Table 1. Characteristics of Respondents

No.	*Characteristis of Respondents*	*Frequency*	*Percentage*
1	*By Gender*		
	Woman	*2*	*7%*
	Men	*28*	*93%*
	Total	*30*	*100%*
2	*By Age*		
	25-35 years	*7*	*23%*
	36-45 years	*11*	*37%*
	> 45 years	*12*	*40%*
	Total	*30*	*100%*
3	*By Position*		
	Engineering Experts	*22*	*73%*
	Project Manager	*3*	*10%*
	Supervisor	*5*	*17%*
	Total	*30*	*100%*
4	*Based on Recent Education*		
	High School/Equivalent	*3*	*10%*
	Bachelor	*27*	*90%*
	Total	*30*	*100%*

Source: Primary data processed, 2023

Based on this description, it can be seen that the majority of respondents in this study are men with the age of > 45 years with the majority having positions as technical experts and the last education, namely Bachelor.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

B. Identification of Work Accident Risk in Tukad Ayung Bridge Replacement Project

Based on the results of observations and interviews that have been conducted by researchers related to identifying the risk of work accidents in the Tukad Ayung bridge replacement project. The work that is the focus of this risk identification is the installation of concrete girders. Identification of the risk of work accidents for concrete girder installation work in the Tukad Ayung Bridge replacement project based on the method of implementing work consisting of seven stages of work. The seven stages of work on the concrete girder installation work of the Tukad Ayung Bridge replacement project along with 24 possible risks can be described as follows.

1) The concrete girder preparation stage, where there are risks that include:
   a. Workers impaled by fragments of material
   b. Workers or communities are hit by concrete girders.
   c. Girders are dropped or impacted.
   d. Collision of heavy equipment/vehicles transporting concrete girders.
2) Scaffolding Manufacturing Stage (*girder truss*), where there are risks that include:
   a. Workers or communities hit by blocks
   b. Workers pinched beams
   c. Scaffolding fell on workers
3) Erection *stage* (*Setting segmental girder*) where there are risks that include:
   a. Workers or communities hit by blocks
   b. Worker falls from a height
   c. Engine malfunction due to overload
4) Strand Installation Stage where there are risks that include:
   a. Workers or communities pierced by prestressed steel
   b. Worker falls from a height
   c. Workers exposed to burrs
5) Strand *Cable Stressing Work Stage* where there are risks that include:
   a. Worker falls from a height
   b. Workers or the public are ejected by broken strand cables
   c. Worker punctured end of kable *strand*
   d. Material falling from a height
6) Tendon grouting *stage* of concrete girder blocks where there are risks that include:
   a. Workers exposed to chemicals
   b. Workers crushed by *grouting machines*
   c. Exposure to other materials/materials
7) Diaphragm Installation Stage where there are risks that include:
   a. Worker falls from a height
   b. Pinched workers
   c. Workers crushed by falling machines
   d. Workers crushed by diaphragm material, falling from a height

C. Work Accident Risk Assessment at Tukad Ayung Bridge Replacement Project

Risk assessment is carried out by distributing questionnaires containing questions that aim to determine the risk assessment of respondents used in this research. Respondents used in this study include Project Managers, Technical Experts and Supervisors both who are directly involved in the Tukad Ayung Bridge Replacement project and who are not involved in the work but have knowledge related to bridge construction work.

Previously, validity and reliability testing was first carried out on the questionnaire used as a research instrument in this study. Based on the results of the validity test, it can be seen that the risk indicators in the assessment of the level of likelihood and severity used in this study have a correlation coefficient value greater than 0.30 with a significance value smaller than 0.05. This shows that the statement items in the research instrument are valid and suitable for use as a research instrument. Based on the results of reliability tests, it can be seen that all indicators used in this study have a Cronbach's Alpha coefficient of more than 0.70. Thus, it can be stated that the research instrument has met the requirements of reliability or reliability so that it can be used for further analysis.

This risk level analysis is a way to categorize risks into groups based on their level of risk. To determine the category of variables is to use the risk categorization table referring to AS/NZS 4360:2004. Before conducting a risk level analysis, an assessment of the level of likelihood (likelyhood) and severity (severity) was previously carried out based on the results of the questionnaire distribution. The calculation begins by determining the percentage of probability and severity of a risk then continues by entering the probability level based on the percentage category presented in Table 2.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Table 2. Determination of Likelihood and Severity Levels

Probability/Severity Values	*Rating Scale*	*Level*
0% < n ≤ 20%	*Very Low (VL)*	*1*
21% < n ≤ 40%	*Low (L)*	*2*
41% < n ≤ 60%	*Moderate (M)*	*3*
61% < n ≤ 80%	*High (H)*	*4*
81% < n ≤ 100%	*Very High (VH)*	*5*

Source: Wirantika (2022)

Where n is the percentage value of the degree of probability and severity obtained based on the calculations made. After obtaining the value of the level of probability and severity, then multiplication is carried out between probability and severity (L x S) so that the level of risk can be determined. One example of the calculation is as follows.

1. Calculation of the Probability Level (L) of Risk R1
   Total score = 76
   Number of data = 30
   Highest answer = 5
   Probability rate formula:
   $$L = \frac{Total\ Skor}{Total\ of\ Data\ x\ highest\ score}\ x\ 100\%$$
   $$= \frac{76}{30\ x\ 5}\ x\ 100\% = 51\%$$
   The result of calculating the probability rate of 51% based on table 2 is at level 3 or LR1 = 3
2. Calculation of Severity Level (S) Risk R1
   Total score = 76
   Number of data = 30
   Highest answer = 5
   Probability rate formula:
   $$S = \frac{Total\ Skor}{Total\ of\ Data\ x\ highest\ score}\ x\ 100\%$$
   $$= \frac{76}{30\ x\ 5}\ x\ 100\% = 51\%$$
   The result of calculating the severity rate of 51% based on table 2 is at level 3 or SR1 = 3

Based on the calculation of L and S on risk R1, the level of risk R1 is obtained as follows:
Risk Level R1 = L x S = 3 x 3 = 9

The product of L and S at risk R1 produces a value of 9, meaning that based on the level of risk, the value shows R1 is at a high level. Further calculations for all risks identified in this study can be seen in the appendix. The table of results of the overall level of risk in this study is as follows.

Table 3. Risk Level Analysis

Code	*Phase Work*	*Risiko*	*L*	*S*	*Risk Level*
R1	*Concrete girder preparation*	*Workers impaled by fragments of material*	*3*	*3*	*High*
R2		*Workers or communities crushed by concrete girders*	*4*	*2*	*High*
R3		*Girders dropped or impacted*	*2*	*3*	*Moderate*

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

R4		*Collision of heavy equipment/vehicles transporting concrete girders*	*2*	*2*	*Moderate*
R5	*Scaffolding Manufacturing Stage (girder truss)*	*Workers or communities hit by blocks*	*4*	*2*	*High*
R6		*Workers pinched beams*	*2*	*3*	*Moderate*
R7		*Scaffolding fell on workers*	*2*	*4*	*High*
R8	*Erection Stage (Setting segmental girder)*	*Workers or communities hit by blocks*	*4*	*3*	*High*
R9		*Worker falls from a height*	*4*	*2*	*High*
R10		*Engine malfunction due to overload*	*4*	*4*	*Extreme*
R11	*Prestressed Steel Mounting Stage (Strand)*	*Workers or communities pierced by prestressed steel*	*4*	*3*	*High*
R12		*Worker falls from a height*	*4*	*2*	*High*
R13		*Workers exposed to burrs*	*4*	*2*	*High*
R14	*Strand Cable Stressing Work Stage*	*Worker falls from a height*	*3*	*2*	*Moderate*
R15		*Workers or the public are ejected by broken strand cables*	*3*	*4*	*High*
R16		*Worker punctured end of kable strand*	*2*	*3*	*Moderate*
R17		*Material falling from a height*	*3*	*2*	*Moderate*
R18	*Grouting stage tendon concrete girder block*	*Workers exposed to chemicals*	*3*	*2*	*Moderate*
R19		*Workers crushed by grouting machines*	*2*	*3*	*Moderate*
R20		*Exposure to other materials/materials*	*2*	*3*	*Moderate*
R21	*Diaphragm Installation Stage*	*Worker falls from a height*	*3*	*2*	*Moderate*
R22		*Pinched workers*	*4*	*2*	*High*
R23		*Workers crushed by falling machines*	*2*	*3*	*Moderate*
R24		*Workers crushed by diaphragm material fall from a height*	*3*	*2*	*Moderate*

Source: Primary data processed (2023)

Based on Table 3. It can be seen that of the 24 risks identified, these risks are at moderate, high, and extreme levels. The following is presented risk mapping based on risk categories presented in Table 4.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Table 4. Risk Mapping by Risk Category

Probability / likelihood ofhazard	*Severity of hazard*				
	Insignificant (1)	*Minor (2)*	*Moderate (3)*	*Major (4)*	*Catastropic (5)*
Rare (1)					
Unlikely (2)		*Moderate (R4)*	*Moderate (R3, R6, R16, R19, R20, R23)*	*High (R7)*	
Prosibble (3)		*Moderate (R14, R17, R18, R21, R24)*	*High (R1, R15)*		
Likely (4)		*High (R2, R5, R9, R12, R13 R22)*	*High (R11, R8)*	*Extreme (R10)*	
Almost certain (5)					

Source: Primary data processed (2023)

Based on Table 4, it can be seen that the majority of risks identified in the concrete girder installation work in the Tukad Ayung Bridge replacement project are in the moderate category, which is as many as 12 risks with a percentage of 50%. Furthermore, as many as 11 risks are included in the high category with a percentage of 45.83%. Meanwhile, in the extreme category as much as one risk with a percentage of 4.17%.

D. Control of Work Accident Risk in Tukad Ayung Bridge Replacement Project

After identifying hazards and risk assessments, the next step is to determine risk controls. Risk control is the final stage in data processing using the HIRARC method. Risk control aims to provide solutions to risks that have been identified and whose levels are known. Regarding risk control, priority is given to risk levels from medium to high, while low risk levels are ignored. Based on the analysis carried out in the Focus Group Discussion (FGD) with K3 Risk Expert sources, alternative risk controls were obtained to minimize the possibility of the risk of work accidents occurring or appearing in the Tukad Ayung bridge replacement project. Regarding risk control that can be carried out from the three levels of risk found, namely moderate, high and extreme, namely by reducing risk through administrative control, engineering control and warning systems.

IV. CONCLUSION

Based on the results of research and discussion that have been described, it can be concluded that:

a. There are 24 risks of work accidents identified in concrete girder work in the Tukad Ayung bridge replacement project, namely 1) The concrete girder preparation stage, there are four risks, 2) The stage of making scaffolding (girder truss), there are three risks, 3) The erection stage (setting segmental girder) there are three risks, 4) The stage of laying prestressed steel (cable strand) there are three risks, 5) The stage of stressing cable strand work There are four risks, 6) The tendon grouting stage of the concrete girder block has three risks, 7) The diaphragm installation stage has four risks.

b. Based on the risk identification that has been carried out, related to the risk assessment of work accidents in girder work in the Tukad Ayung Bridge replacement project, it can be seen that the majority of risks identified in concrete girder work in the Tukad Ayung Bridge replacement project are in the moderate category, which is as many as 12 risks with a percentage of 50%. Furthermore, as many as 11 risks are included in the high category with a percentage of 45.83%. Meanwhile, in the extreme category as much as one risk with a percentage of 4.17%.
c. Based on risk assessment on possible risks that occur or arise in the Tukad Ayung Bridge replacement project, there is risk control that can be done from the three levels of risk found, namely moderate, high, and extreme, namely by reducing risks through administrative control, engineering control , and warning systems.

REFERENCES

Agus Koreawan, O., & Basuki, M. (2019). Identifikasi Bahaya Bekerja Dengan Pendekatan Hazard Identification Risk Assessment And Risk Control (HIRARC) Di PT. Prima Alloy Steel Universal. Seminar Nasional Inovasi Dan Aplikasi Teknologi Di Industri 2019, 161–165.

Agusliadi. (2010). Kecelakaan - kecelakaan Kerja Pada Perusahaan Konstruksi.

Arikunto, S. (2010). Prosedur Penelitian Suatu Pendekatan Praktek. Rineka Cipta.

Arya, I. G. (2021). Optimasi pelaksanaan reklamasi.

Ayunita, D. N. . (2018). Modul Uji Validiitas dan Reliabilitas. 1–15. https://jurnal.uin-antasari.ac.id/index.php/jtjik/article/download/2100/1544

Bayu Dharma, A. A., Adnyana Putera, I. G. A., & Parami Dewi, A. A. D. (2017). Manajemen Risiko Keselamatan Dan Kesehatan Kerja (K3) Pada Proyek Pembangunan Jambuluwuk Hotel & Resort Petitenget. Jurnal Spektran, 5(1), 47–55. https://doi.org/10.24843/spektran.2017.v05.i01.p06

Gunawan, A. A., & Bendatu, L. Y. (2015). Perbaikan Keselamatan dan Kesehatan Kerja Dengan Metode HIRARC di PT . Sumber Rubberindo Jaya. Jurnal Titra, 3(2), 421–426. http://publication.petra.ac.id/index.php/teknik-industri/article/view/3528/3198

Halim, L. N., & Panjaitan, T. W. S. (2016). Perancangan Dokumen Hazard Identification Risk Assessment Risk Control (HIRARC) Pada Perusahaan Furniture. Jurnal Titra, 4(2), 279–284.

Hermawati, E. (2008). Faktor - faktor yang berhubungan dengan kejadian kecelakaan kerja berdasarkan karakteristik pekerja dan unit kerja di area pertambangan PT. Antam Tbk Ubpe pongkor Bogor Jawa Barat Tahun 2006 - 2007.

Irawan, S., W. S. Panjaitan, T., & Yenny Bendatu, L. (2015). Penyusunan Hazard Identification Risk Assessment and Risk Control (HIRARC) di PT. Jurnal Titra, 3(1), 15–18.

Muka, I. W. (2015). Analisis Risiko pada Proyek Pembangunan Parkir Basement Jalan Sulawesi Denpasar. Analisis Risiko Pada Proyek Pembangunan Parkir Basement Jalan Sulawesi Denpasar, 19(2), 155–165. https://doi.org/10.14710/mkts.v19i2.8425

Nursyachbani, P. A., & Susanto, N. (2018). Analisis Risiko Kecelakaan Kerja pada Proyek Underpass Jatinengaleh Semarang dengan Metode Failure Mode and Effect Analysis (FMA). Industrial Engineering Online Journal, 6(4), Hal. 1-7. http://garuda.ristekbrin.go.id/documents/detail/1420769

Undang - Undang Nomor 1 Tahun 1970 Tentang Keselamatan Kerdja, Kementerian Tenaga Kerja dan Transmigrasi RI (1970).

Purnama, D. S. (2015). Analisia Penerapan Metode Hirarc (Hazard Identification Risk Assessment and Risk Control) Dan Hazops (Hazard and Operability Study) Dalam Kegiatan Identifikasi Potensi Bahaya Dan Risiko Pada Proses Unloading Unit Di Pt. Toyota Astra Motor. Jurnal PASTI, IX(3), 311–319.

Ramadhan, F. (2017). Analisis Kesehatan dan Keselamatan Kerja (K3) menggunakan metode Hazard Identification Risk Assessment and Risk Control (HIRARC). Seminar Nasional Riset Terapan, November, 164–169.

Saraswati, N. P. yolanda, & Widodo, S. (2017). Penerapan Metode HIRARC Keselamatan dan Kesehatan Kerja Pada Pekerjaan Land Clearing Di Termina Kijing Kabupaten Mempawah.

Sari, N., Mulyani, E., & M.Nuh, S. (2016). Manajemen Risiko Keselamatan Dan Kesehatan Kerja Pada Pekerjaan Konstruksi. Jurnal Mahasiswa Teknik Sipil Universitas Tanjungpura, 2(2), 1–14. http://jurnal.untan.ac.id/index.php/JMHMS/article/view/16159/14071

Setiyadi. (2012). Analisis Faktor Risiko Penyebab Kecelakaan Kerja Jatuh Pada Proyek Konstruksi di Jabodetabek.

Socrates, M. F. (2013). Analisis Risiko Keselamatan Kerja Dengan Metode Hirarc (Hazard Identification, Risk Assessment and Risk Control).

Supriyadi, Nalhadi, A., & Rizal, A. (2015). Identifikasi Bahaya dan Penilaian Risiko K3 Pada Tindakan Perawatan dan Perbaikan Menggunakan Metode HIRARC (Hazard Identification And Risk Assesment Risk Control) pada PT. X. Seminar Nasional Riset Terapan, July, 281–286. https://e-jurnal.lppmunsera.org/index.php/senasset/article/view/474

Wahyuni, P. I., Suranata, putu gede, & Triswandana, P. G. E. (2019). Kajian Manajemen Risiko dalam Proyek Kerjasama Pemerintah Swasta (KPS)/ Kerjasama Pemerintah Badan Usaha (KPBU) dengan Menggunakan Metode House Of Risk (HOR). KoNTekS-13, I, 618–625.

Wiyasa, I. W., Adnyana Putera, I. G. A., & Nadiasa, M. (2015). Manajemen Risiko Keselamatan Dan Kesehatan Kerja (K3) Pada Proyek Pembangunan Ciputra World Jakarta. Jurnal Spektran, 3(1), 1–9. https://doi.org/10.24843/spektran.2015.v03.i01.p01