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SAFETY IMPLEMENTATION ANALYSIS AND OCCUPATIONAL HEALTH AT KRETEK 2 BRIDGE WORK IN BANTUL REGENCY

Isyraq Nashrullah Arifin, Wateno Oetomo, Laksono Djoko Nugroho
Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: isyraqnasrullah69@gmail.com, wateno@untag-sby.ac.id, laksonodjoko@untag-sby.ac.id

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Bridge, Occupational Safety and Health, HIRADC.

ABSTRACT

Construction work includes the implementation of construction work and the community organizing the construction work itself. The implementation of this construction work must comply with the provisions regarding engineering, occupational safety and health, labor protection, and local environmental regulations to ensure the realization of an orderly implementation of construction work. The construction of the Kretek 2 Bridge in Bantul Regency, Special Region of Yogyakarta Province has its own challenges, because the location of the bridge is in an area prone to earthquakes and liquefaction or ground movement. With so many workers on this very high-risk project, there is a high probability of an accident occurring. The purpose of the study was to analyze (1) the risky work that could occur in bridge construction work, (2) the work that has the highest possible risk, (3) risk control, (4) the amount of investment costs required. The method used is the HIRADC method. The results of the study were (1) Risky work that can occur was a. High level of risk, including drowning, being dragged by the river current, being hit by heavy equipment maneuvers and falling from a height. b. Moderate risk level, including being crushed by formwork, falling material, scratched hands. c. Low level of risk, including landslides, heavy equipment maneuvers, iron puncture. (2) Work that has the highest possible risk is Pile Cap Excavation Work, Work Floor Work and Pier Head Ironing Work. (3) Risk control in bridge work consists of: Using a boat when measuring in rivers, Conducting briefings before starting activities, Using PPE life vests and placing life ring buoys on boats, Installing signs and placing officers in areas that intersect with roads, Installing guardrail of the project area, installing scaffolding as a working platform and inspecting its feasibility, communicating hazards through signs, conducting refresh training for workers. (4) The investment cost required for implementing K3 on the Kretek 2 Bridge work in Bantul Regency was Rp. 6,545,998,310 or 1.795% of the contract value.

INTRODUCTION

Indonesia is one of the developing countries, development and development in the construction sector have increased. The Ministry of Public Works and Public Housing (PUPR) through the Directorate General of Wildlife Development is completing the construction of the Kretek 2 Bridge located in Bantul, Yogyakarta Special Region (DIY). The bridge with a total length of 2.01 km spans the Opak River and connects Tirtohargo Village with Parangtritis Village. This bridge is part of the 1,604 km Long Java South Coast Road which is famous for its coastal tourism area that stretches from Banten to East Java.

The construction of the Kretek 2 Bridge has its own challenges because the location of the bridge is in an area prone to earthquakes and liquefaction or soil movement. With

a lot of workers on the project that can be said to be very high-risk, it is not impossible to the possible risk of accidents. In accordance with the requirements of OHSAS 18001, organizations must obtain procedures regarding hazard identification, risk assessment, and determining control or HIRADC for short. This whole process is called risk management. HIRADC is a method used to identify and analyze potential hazards and provide risk assessments that will later be considered regarding the level of danger.

To find out more about the risk of accidents or dangers that will occur and the level of possibility, research is needed that aims to:

1.Analyzing risky work, 2. Analyze the work that has the highest possible risk, 3. Analyzing ways of risk control, 4. Analyzing the large investment costs required for the application of K3 on the Kretek 2 Bridge work in Bantul Regency

RESEARCH METHOD

Occupational Health and Safety (K3)

Occupational Safety and Health (K3) is a condition or factor that affects or may affect the health and safety of workers or other workers (including temporary workers and contractors), visitors, or any person in the workplace. (Ramli, 2013)

Risk

Risk can be associated with the possibility of unintended adverse consequences or uncertainty. This is a condition that causes the growth of risks stemming from various activities and may affect the cost, schedule and quality of projects (Darmawi, 2008)

Danger

Danger is a source, situation, or action that could potentially cause human accidents or injuries, damage, or other disturbances. According to Ramli (2010) hazards come from the following five factors: 1.Mechanical Hazard, 2.Electrical Hazard, 3.Physical Hazard, 4.Biological Hazard, 5.Chemical Hazard.

Work Accidents

According to the Decree of the Director General of Industrial Relations Development and Manpower Supervision Number 84 of 1998 states that the sources and types of accidents are as follows: 1.Sources of work accidents, 2. Types of accidents

HIRADC (Hazard Identification, Risk Assessment and Determining Control)

Ministerial Regulation Number 21/PRT/M/2019 article 3 paragraph 1 states "Every service user and service provider in the implementation of construction services must apply SMKK". Identifying hazards, conducting risk assessments, and conducting risk control are important requirements in the implementation of SMKK.

Data Analysis Techniques

Determination of Respondent Sample

The determination of the sample of respondents used is intentional sampling or purposive sampling (Andriani, 2017). Purposive sampling is sampling whose sample members are selected intentionally based on respondents' knowledge of the risks of implementing K3 work on Kretek Bridge 2 in Bantul Regency.

RESULT AND DISCUSSION

Probability Analysis

Probability is a measure of the likelihood that a future event will occur. Probability only has a value between 0 and 1. The scale used for this method uses a likert scale, with a range of numbers 1-5 as in the following table:

Table 1 Possibilities with a Likert Scale

Information	Measurements with Likert Scale	Criterion	
		Quantitative Criteria	Qualitative Criteria
Very Rare	1	≤ 20	Less occurrence, only under certain conditions
Sometimes It Happens	2	21-40	Sometimes occurs in conditions certain
May Happen	3	41-60	Occurs under certain conditions
Frequent	4	61-80	Frequent occurrence of every condition
Almost Certainly Happened	5	81-100	Always happens in every condition

Source: Ramli (2013)

2. Impact Analysis with Likert Scale

Impact is an event that exerts an influence, both adverse and beneficial influence. The impact in question is something that will be received or obtained by individual accident victims or companies communally.

Table 2 Impact with a Likert Scale

Information	Measurements with Likert Scale	Criterion	
		Quantitative Criteria	Qualitative Criteria
Insignificant	1	≤ 20	Not so significant losses, minor injuries (bad influences can be ignored)
Small	2	21-40	Minor injuries; Requires P3K treatment (directly can be handled at the scene); moderate material losses.
Keep	3	41-60	Moderate injuries; Loss of working days; Requires medical treatment; Material losses are considerable
Heavy	4	61-80	Major injuries; Defects result in defects or complete loss of body function, large material losses.
Disaster	5	81-100	Death, huge material losses

Source: Ramli (2013)

3. *Severity Index* Analysis

The severity index is used to determine the significant risks to both items, namely probability and impact. Severity index is calculated using the equation

Severity Index Formula for *Probability*:

$$SI(p) = \frac{\sum_{i=1}^{5} a_i x_i}{\sum_{i=1}^{5} x_i}(100\%) \quad (1)$$

where:

SI(p)= *Severity Index* for *Probability*
a_i = Assessment constant
x_i = Respondent Frequency
i= 1, 2, 3, 4, 5,... n
x_1, x_2, x_3, x_4, x_5 are respondents' frequency responses
x_1 = Frequency of respondents "Very Rare," then a_1= 1
x_2 = Frequency of respondents "Sometimes It Happens," then a_2 = 2
x_3 = Respondent frequency "May Occur," then a_3 = 3
x_4 = Frequency of respondents "Frequent Occurrence," then a_4 = 4
x_5 = Respondent frequency "Almost Certainly Happens," then a_5 = 5

Severity Index Formula for *Impact*:

$$SI(i) = \frac{\sum_{i=1}^{5} a_i x_i}{\sum_{i=1}^{5} x_i}(100\%) \quad (2)$$

where:
SI(i)= *Severity Index* for *Impact*
a_i = Assessment constant
x_i = Respondent Frequency
i= 1, 2, 3, 4, 5..., n
x_1, x_2, x_3, x_4, x_5 are respondents' frequency responses
x_1 = Frequency of respondents "Insignificant," then a_1= 1
x_2 = Frequency of respondents "Small," then a_2 = 2
x_3 = Frequency of respondents "Moderate," then a_3 = 3
x_4 = Frequency of respondents "Weight," then a_4 = 4
x_5 = Frequency of respondents "Disaster," then a_5 = 5

4. Assessment of Employment Risk Level

After obtaining the results of the *Severity Index* and the level of classification, the matrix value is obtained in accordance with the provisions that have been applied as follows:

Table 3 Category Matrix Possibilities

Category	SI (%)	Possible Matrix Level
Almost Certainly Happened	81-100	5
Frequent	61-80	4
May Happen	41-60	3
Sometimes It Happens	21-40	2
Very Rare	≤ 20	1

Source: Ramli (2013)

Table 4 Impact Matrix Categories

Category	SI (%)	Impact Matrix Level
Disaster	81-100	5
Heavy	61-80	4
Keep	41-60	3
Small	21-40	2

Category	SI (%)	Impact Matrix Level
Insignificant	≤20	1

Source: Ramli (2013)

Once converted into probability and impact matrix levels, the two values are multiplied to plot on the matrix, so that they will get the risk level. The risk level in question is the level of risk obtained from the calculation of the probability that will occur and the amount of influence that will be received. The purpose of this probability and impact matrix is to find out which risks are likely to occur and have a big impact on the project with the scale used is a matrix of values 1-25.

To find out the measure of risk, probability and impact can be plotted in a risk matrix, using the equation:

R = P x I (3)

where:

R : *Leveling Risk*

P : *Probability*

I : *Impact*

The result of the matrix is to determine the risk level from each identification of possible risks that can occur. Then from the known risk level, it will also be taken into account in planning its handling on the risk response.

Determining Control

The next stage is to determine the controls used to reduce or eliminate the impact of the risk of imminent harm in a project. Control is carried out based on five levels as follows:

1. Elimination
   The method of elimination is a method of risk control that if possible should eliminate or completely remove processes or materials that may cause the presence of harm
2. Substitution
   The substitution method is a method of controlling hazards by replacing work or tools with others that have less danger
3. Engineering Control Methods of hazard control that protect workers from hazards such as providing the placement of materials, materials, signs, checking tools and maintenance of tools and materials to be used
4. Administrative (Administrative) Control of risks and hazards in the form of regulations related to occupational safety and health made such as conducting periodic K3 inspections, toolbox meetings, conducting training, safety morning, SOPs and supervision
5. Personal Protective Equiepment (PPE) The most recent hazard control is to use personal protective equipment or PPE. This latest hazard control is less effective but must be done for smooth running and safety of work on the condition that you use complete personal protective equipment to minimize workers from being injured

Develop HIRADC *(Hazard Identification, Risk Assessment and Determining Control)*

After collecting various data from hazard identification, risk level assessment and risk control, then compiling a HIRADC able which will be used to determine the value of the risk level of danger that occurs in the bridge pillar structure work as a research object. In able HIRADC made more detailed along with the implementation method to get more detailed results. 378378378378

Investment Costs of K3 Implementation

After observation of the application of K3 control, then the calculation of the investment cost needs of the occupational safety and health management system (SMK3) was carried out based on the Circular Letter of the Minister of Public Works Number: 66 / SE / M / 2015, concerning investment costs for the Implementation of the K3 Construction System in the Field of Public Works.

The investment costs required for theimplementation of K3 on the Kretek 2 Bridge work in Bantul Regency include:

1. RKK Setup
2. Socialization, Promotion and training
3. Work Protective Equipment and Personal Protective Equipment
4. Insurance and Licensing
5. Construction Safety Personnel
6. Health facilities and infrastructure
7. Health Programs
8. Prevention of Covid-19
9. Handling Covid-19
10. Signs
11. Consultation with a Construction Safety expert
12. Miscellaneous Related to K3 Risk Control
13. Industrial Hygiene and Environmental Monitoring
14. General and Operational

ANALYSIS

Results of Identification of Risky Work

The risk identification stage is based on the *standard of procedure* (SOP) of each job. Starting from the implementation stage, the tools used, and the materials used.

Table 5 Results of Identification of Risky Work

No.	Jobs at Risk	Danger
1	Pile Cap Excavation Work	
1.1	Measurement	a. Danger from the attack of a poisonous animal
		b. Mired
		c. Struck by lightning
		d. Drowning dragged by the current of the river
1.2	Excavation work	a. Landslide
		b. Machine maneuvering
2	Work Floor Work	
2.1	Installation of stakes	a. Hand hit by hammer
		b. Respiratory disorders
		c. Material fall
2.2	Cleaning and tillage with heavy equipment (Dozzer, excavator, vibro)	a. Exposed to machine maneuvers
		b. Respiratory disorders
		c. Material fall
2.3	Heap and compaction work	a. Exposed to machine maneuvers
		b. Respiratory disorders
		c. Material fall

No.	Jobs at Risk	Danger
3	Pile cap fixing work	
3.1	Elevation measurement	a. Exposed to flakes of iron material
		b. Fall of iron material
3.2	Installation of stakes	a. Hand hit by hammer
		b. Respiratory disorders
		c. Material fall
4	Pillar Fixing Work	
4.1	Scaffolding mounting	a. Scratched hand
		b. Stuck
		c. Crushed by tools and materials
		d. Falling from a height
5	Pier Head Cleaning Work	
5.1	Elevation measurement	a. Hands scratched iron
		b. Pinched hands
		c. Falling from a height
6	Iron Fabrication Work	
6.1	Iron cutting with barbender	a. Electrocuted
		b. Fingers of the hand cut off the gear
		c. Iron punctured
		d. Pinched hands
7	Foundry Works	
7.1	Casting using mixer truck	a. Mired Mixer Truck
		b. Concrete pump mired and rolled over
		c. Falling from a height
8	Formwork Installation Work	
8.1	Installation of bridge pillar formwork	a. Hands scratched iron
		b. Hand pinched formwork
		c. Exposed to manual work tools
		d. Stricken with formwork
		e. Dropped from a height
9	Formwork Demolition Work	
9.1	Formwork Demolition	a. Hands scratched iron
		b. Hand pinched formwork
		c. Exposed to manual work tools
		d. Falling from a height

Source: RKK Paket Lot 3 Jembatan Kretek 2 in Bantul Regency

Table 4 shows the results of the identification of the Risk of Kretek Bridge Construction 2 in Bantul Regency, which consists of 9 occupational risks, namely (1) pile cap excavation work, (2) Work floor work, (3) Pile cap fixing work, (4) Pillar cleaning work, (5) Pier head fixing work, (6) Iron fabrication work, (7) Foundry work, (8) Formwork installation work and (9) Formwork demolition work.

Results of the Identification of Risky Work Questionnaire

The assessment was given by 20 respondents who had been determined based on the experience and thoughts of each respondent.

Table 6 Results of the Pile Cap Excavation Work Risk Level Questionnaire

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
1	Pile Cap Excavation Work												
1.1	Measurement												
	a. Danger from the attack of a poisonous animal	20	0	0	0	0	20	0	1	5	5	9	20
	b. Mired	0	2	2	9	7	20	20	0	0	0	0	20
	c. Struck by lightning	20	0	0	0	0	20	0	1	4	5	10	20
	d. Drowning dragged by the current of the river	4	4	5	7	0	20	0	3	4	5	8	20
1.2	Excavation work												
	a. Landslide	8	7	4	1	0	20	10	8	2	0	0	20
	b. Machine maneuvering	20	0	0	0	0	20	3	6	4	7	0	20

Source: Data processing results

Table 7 Results of the Work Floor Work Work Risk Level Questionnaire

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
2	Work Floor Work												
2.1	Installation of stakes												
	a. Hand hit by hammer	8	6	5	1	0	20	7	7	5	1	0	20
	b. Respiratory disorders	20	0	0	0	0	20	8	7	5	0	0	20
	c. Material fall	8	8	3	1	0	20	8	9	2	1	0	20
	d. Drowning dragged by the current of the river	8	6	5	1	0	20	7	7	5	1	0	20
2.2	Cleaning and tillage with heavy equipment (Dozzer, excavator, vibro)												
	a. Exposed to machine maneuvers	7	7	5	1	0	20	2	6	6	6	0	20
	b. Respiratory disorders	8	6	4	2	0	20	20	0	0	0	0	20
	c. Material fall	9	5	4	2	0	20	9	6	4	1	0	20
2.3	Heap and compaction work												
	a. Exposed to machine maneuvers	9	5	5	1	0	20	4	5	6	5	0	20
	b. Respiratory disorders	9	6	4	1	0	20	20	0	0	0	0	20

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
	c. Material fall	8	7	~~5~~	0	0	20	9	9	1	1	0	20

Source: Data processing results

Table 8 Pile Cap Fixing Job Risk Level Questionnaire Results

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
3	Pile Cap Fixing Work												
3.1	Elevation measurement												
	a. Exposed to flakes of iron material	8	7	4	1	0	20	20	0	0	0	0	20
	b. Fall of iron material	9	8	2	1	0	20	8	8	4	0	0	20
3.2	Installation of stakes												
	a. Hand hit by hammer	8	5	~~4~~	3	0	20	12	6	2	0	0	20
	b. Respiratory disorders	8	5	~~4~~	1	0	18	20	0	0	0	0	20
	c. Material fall	9	7	~~4~~	0	0	20	9	8	2	1	0	20

Source: Data processing results

Table 9 Results of the Questionnaire on the Risk Level of Pillar Fixing Work

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
4	Pillar Fixing Work												
4.1	Scaffolding mounting												
	a. Scratched hand	7	6	4	3	0	20	7	7	6	0	0	20
	b. Pinched hands	7	7	3	3	0	20	8	8	4	0	0	20
	c. Crushed by tools and materials	8	5	~~6~~	1	0	20	12	6	2	0	0	20
	d. Falling from a height	8	7	~~4~~	1	0	20	2	2	8	8	0	20

Source: Data processing results

Table 10 Pier Head Fixture Work Risk Level Questionnaire Results

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
5	Pier Head Cleaning Work												
5.1	Elevation measurement												
	a. Hands scratched iron	8	6	5	1	0	20	6	6	6	2	0	20
	b. Pinched hands	6	6	4	4	0	20	8	8	3	1	0	20
	c. Falling from a height	9	5	5	1	0	20	1	1	2	7	9	20

Source: Data processing results

Table 11 Results of the Iron Fabrication Work Risk Level Questionnaire

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
6	Iron Fabrication Works												
6.1	Iron cutting with barbender												
	a. Electrocuted	8	6	4	2	0	20	5	5	6	4	0	20
	b. Fingers of the hand cut off the gear	6	5	4	5	0	20	8	7	3	2	0	20
	c. Iron punctured	8	6	5	1	0	20	9	7	2	2	0	20
	d. Pinched hands	5	5	5	5	0	20	7	7	5	1	0	20

Source: Data processing results

Table 12 Results of the Foundry Job Risk Level Questionnaire

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
7	Foundry Works												
7.1	Casting using mixer truck												
	a.Mired mixer truck	8	6	5	1	0	20	4	5	5	6	0	20
	b. Concrete pump mired and rolled over	8	6	4	2	0	20	6	7	3	4	0	20
	c. Falling from a height	10	7	2	1	0	20	3	7	2	8	0	20

Source: Data processing results

Table 13 Results of the Questionnaire on the Level of Risk of Formwork Installation Work

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
8	Formwork Installation Work												
8.1	Installation of bridge pillar formwork												
	a. Hands scratched iron	4	4	6	6	0	20	7	7	5	1	0	20
	b. Hand pinched formwork	8	6	4	2	0	20	8	7	4	1	0	20
	c. Exposed to manual work tools	7	8	4	1	0	20	8	8	1	3	0	20
	d. Stricken with formwork	6	5	6	3	0	20	3	7	3	7	0	20
	e. Dropped from a height	3	3	7	7	0	20	2	6	5	7	0	20

Source: Data processing results

Table 14 Results of the Questionnaire on the Level of Risk of Formwork Demolition Work

No.	Work Risks of the Stage of Work	Likelihood 1 SJT	2 KT	3 DT	4 ST	5 HPT	Total	Impact 1 TS	2 K	3 S	4 T	5 B	Total
9	Formwork Demolition Work												
9.1	Formwork Demolition												
	a. Hands scratched iron	4	4	5	7	0	20	20	0	0	0	0	20
	b. Hand pinched formwork	3	4	4	9	0	20	20	0	0	0	0	20
	c. Exposed to manual work tools	3	3	~~6~~	8	0	20	20	0	0	0	0	20
	d. Falling from a height	4	3	~~4~~	9	0	20	3	6	3	8	0	20

Source: Data processing results

Assessment of the Level of Employment Risk

Table 15 Results of Risk Level Assessment of Pile Cap Excavation Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
1	Pile Cap Excavation Work									
1.1	Measurement									
	a. Danger from the attack of a poisonous animal	20	100	20%	1	82	100	82%	5	Keep
	b. Mired	81	100	81%	5	20	100	20%	1	Keep
	c. Struck by lightning	20	100	20%	1	84	100	84%	5	Keep
	d. Drowning dragged by the current of the river	55	100	55%	3	78	100	78%	4	Tall
1.2	Excavation work									
	a. Landslide	38	100	38%	2	32	100	32%	2	Low
	b. Machine maneuvering	20	100	20%	1	55	100	55%	4	Low

Source: Data processing results

Table 16 Results of the Assessment of the Risk Level of Work Floor Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
2	Work Floor Work									
2.1	Installation of stakes									
	a. Hand hit by hammer	39	100	39%	2	40	100	40%	2	Low
	b. Respiratory	20	100	20%	1	37	100	37%	2	Low

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
	disorders									
	c. Material fall	37	100	37%	2	36	100	36%	2	Low
	d. Drowning dragged by the current of the river	39	100	39%	2	40	100	40%	2	Low
2.2	Cleaning and tillage with heavy equipment (Dozzer, excavator, vibro)									
	a. Exposed to machine maneuvers	40	100	40%	2	86	100	86%	5	Tall
	b. Respiratory disorders	40	100	40%	2	20	100	20%	1	Low
	c. Material fall	39	100	39%	2	57	100	57%	3	Keep
2.3	Heap and compaction work									
	a. Exposed to machine maneuvers	38	100	38%	2	82	100	82%	5	Tall
	b. Respiratory disorders	37	100	37%	2	20	100	20%	1	Low
	c. Material fall	37	100	37%	2	39	100	39%	2	Low

Source: Data processing results

Table 17 Pile Cap Fixing Work Risk Level Assessment Results

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
3	Pile Cap Fixing Work									
3.1	Elevation measurement									
	a. Exposed to flakes of iron material	38	100	38%	2	20	100	20%	1	Low
	b. Fall of iron material	35	100	35%	2	56	100	56%	3	Keep
3.2	Installation of stakes									
	a. Hand hit by hammer	42	100	42%	3	40	100	40%	2	Keep
	b. Respiratory disorders	34	90	38%	2	20	100	20%	1	Low
	c. Material fall	35	100	35%	2	45	100	45%	3	Keep

Source: Data processing results

Table 18 Results of the Risk Level Assessment of Pillar Fixing Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
4	Pile Cap Fixing Work									
4.1	Elevation measurement									
	a. Scratched hand	43	100	43%	3	39	100	39%	2	Keep

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
	b. Pinched hands	42	100	42%	3	36	100	36%	2	Keep
	c. Crushed by tools and materials	40	100	40%	2	30	100	30%	2	Low
	d. Falling from a height	38	100	38%	2	62	100	62%	4	Keep

Source: Data processing results

Table 19 Pier Head Cleaning Work Risk Level Assessment Results

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
5	Pier Head Cleaning Work									
5.1	Elevation measurement									
	a. Hands scratched iron	39	100	39%	2	44	100	44%	3	Keep
	b. Pinched hands	46	100	46%	3	37	100	37%	2	Keep
	c. Falling from a height	38	100	38%	2	82	100	82%	5	Tall

Source: Data processing results

Table 20 Results of the Risk Level Assessment of Iron Fabrication Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
6	Iron Fabrication Works									
6.1	Elevation measurement									
	a. Electrocuted	40	100	40%	2	49	100	49%	3	Keep
	b. Fingers of the hand cut off the gear	48	100	48%	3	39	100	39%	2	Keep
	c. Iron punctured	39	100	39%	2	37	100	37%	2	Low
	d. Pinched hands	50	100	50%	3	40	100	40%	2	Keep

Source: Data processing results

Table 21 Results of the Assessment of the Level of Risk of Foundry Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
7	Foundry Works									
7.1	Casting using mixer truck									
	a.Mired mixer truck	39	100	39%	2	53	100	53%	3	Keep
	b. Concrete pump mired and rolled over	40	100	40%	2	45	100	45%	3	Keep
	c. Falling from a height	34	100	34%	2	55	100	55%	3	Keep

Source: Data processing results

Table 22 Results of the assessment of the level of risk of formwork installation work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
8	Formwork Installation Work									
8.1	Installation of bridge pillar formwork									
	a. Hands scratched iron	54	100	54%	3	40	100	40%	2	Keep
	b. Pinched hands	40	100	40%	2	38	100	38%	2	Low
	c. Exposed to manual work tools	39	100	39%	2	39	100	39%	2	Low
	d. Stricken with formwork	46	100	46%	3	54	100	54%	3	Keep
	e. Dropped from a height	58	100	58%	3	57	100	57%	3	Keep

Source: Data processing results

Table 23 Results of the Assessment of the Risk Level of Formwork Demolition Work

No	Work Risks of the Stage of Work	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI(p)	Level Prob.	$\sum_{i=1}^{5} a_i x_i$	$5\sum_{i=1}^{5} x_i$	SI (i)	Level Impact	Level Risk
9	Formwork Demolition Work									
9.1	Formwork Demolition									
	a. Hands scratched iron	55	100	55%	3	20	100	20%	1	Low
	b. Hand pinched formwork	59	100	59%	3	20	100	20%	1	Low
	c. Exposed to manual work tools	59	100	59%	3	20	100	20%	1	Low
	d. Falling from a height	58	100	58%	3	56	100	56%	3	Keep

Source: Data processing results

Grouping of Employment Risk Levels

Grouping of Employment Risk Levels

Based on the assessment of the risk level for each work, the project on the Kretek 2 Bridge construction project in Bantul Regency obtained a grouping of high to low risk levels for each work as follows:

Table 24 Grouping of Employment Risk Levels

No	Work: Job Risk	Job Risk	Level Prob. (P)	Level Impact (I)	Level Risk (P x I)
1	Pile Cap Excavation Work				
	Tall	Drowning dragged by the current of the river	3	4	12

No	Work Job Risk	Job Risk	Level Prob. (P)	Level Impact (I)	Level Risk (P x I)
	Keep	Mired	5	1	5
		Danger from the attack of a poisonous animal	1	5	5
		Struck by lightning	1	5	5
	Low	Landslide	2	2	4
		Machine maneuvering	1	4	4
2		Work Floor Work			
	Tall	Exposed to machine maneuvers	2	5	10
	Keep	Material fall	2	3	6
	Low	Hand hit by hammer	2	2	4
		Material fall	2	2	4
		Drowning dragged by the current of the river	2	2	4
		Respiratory disorders	2	1	2
3		Pile Cap Fixing Work			
	Keep	Hand hit by hammer	3	2	6
		Material fall	2	3	6
	Low	Exposed to flakes of iron material	2	1	2
		Respiratory disorders	2	1	2
4		Pillar Fixing Work			
	Keep	Scratched hand	3	2	6
		Pinched hands	3	2	6
		Dropped from a height	2	2	4
	Low	Crushed by tools and materials	2	2	4
5		Pier Head Cleaning Work			
	Tall	Dropped from a height	2	5	10
	Keep	Pinched hands	3	2	6
		Hands scratched iron	2	3	6
6		Iron Fabrication Works			
	Keep	Fingers of the hand cut off the gear	3	2	6
		Electrocuted	2	3	6
	Low	Iron punctured	2	2	4
7		Foundry Works			
	Keep	Mired mixer truck	2	3	6
		Concrete pump mired and rolled over	2	3	6
		Dropped from a height	2	3	6
8		Formwork Installation Work			
	Keep	Crushed by formwork	3	3	9
		Dropped from a height	3	2	6
		Hands scratched iron	3	2	6
	Low	Exposed to manual labor tools	2	2	4
9		Formwork Demolition Work			

No	Work Job Risk	Job Risk	Level Prob. (P)	Level Impact (I)	Level Risk (P x I)
	Keep	Dropped from a height	3	3	9
	Low	Hands scratched iron	3	1	3
		Hand pinched formwork	3	1	3
		Exposed to manual labor tools	3	1	3

Source: Data processing results

Based on the grouping of occupational risk levels, the construction of Kretek Bridge 2 in Bantul Regency obtained 3 (three) high job risks, 12 (twelve) medium occupational risks and 9 (nine) low job risks.

Risk Control and Preparation of HIRADC

The next stage is to determine the control and preparation of the HIRADC table used to reduce or eliminate the impact of the risk of hazards that will occur on the nine bridge pillar structure works in the Kretek 2 Bantul Bridge Construction, as follows:

CONCLUSION

Based on the objectives of the study, it can be concluded that:

The risky work that can occur in the construction of the Kretek Bridge 2 pillar structure in Bantul Regency is as follows:

High risk levels include: 1. Drowning dragged by river currents, 2. Exposed to machine maneuvers and 3. Dropped from a height

Moderate risk levels include: 1. Being crushed by formwork, 2. Falling material, 3. Scratched hand, 4. Pinched hand, 5. Hand hit by hammer, 6. Fingers of hand cut gear, 7. Electrocuted, 8. Mired mixer truck, 9. Concrete pump mired and rolled over, 10. Mired, 11. Danger from the attack of a poisonous animal and 12. Struck by lightning

Low risk levels include: 1. Landslides, 2. Maneuvering heavy equipment, 3. Punctured iron, 4. Exposed to manual work tools, 5. Crushed tools and materials, 6. Hand pinched formwork, 7. Exposed to manual work tools, 8. Exposed to flakes of iron material and 9. Respiratory disorders

In the implementation of construction, works that have a high potential risk are: 1. Pile Cap Excavation Work, 2. Work Floor Work and 3. Pier Head's Fixing Work.

Risk control on the work of Kretek 2 Bridge in Bantul Regency is as follows:

Control of the risk of drowning dragged by river currents in pile cap excavation work, consisting of: 1. Use of boats when measuring on the river, 2. Conduct briefings before starting activities and 3. Using PPE life vest and placing life ring buoy on the boat

Control of the risk of being exposed to machine maneuvers on work floor work, consisting of: 1. Installation of signs and placement of officers in areas that intersect with the highway and 2. Installation of project area guardrails

Control of the risk of falling from a height on pier head cleaning work, consisting of: 1. Installing the scaffolding as a working platform and inspecting its airworthiness and 2. Hazard communication through signs, 3. Refresh training for workers

The investment cost required for the application of K3 on the Kretek 2 Bridge work in Bantul Regency amounted to Rp 6,545,998,310 (six billion five hundred and forty-five million nine hundred ninety-eight thousand three hundred and ten rupiah) or 1.795% of the contract value of Rp 364,627,810,221, in accordance with the Regulation of the Minister of Public Works Number: 05/PRT/M/2014, which includes:

The implementation of construction with high and low hazard potential must involve a construction K3 Expert (Article 6 of the Pu Regulation Number: 05 / PRT / M / 2014)

The cost of organizing SMK3 Construction PU Field is allocated in general costs which include: a. RKK Preparation, b. Socialization, Promotion and training, c. Work Protective Equipment and Personal Protective Equipment, d. Insurance and Licensing, e. Construction Safety Personnel, f. Health Facilities and infrastructure, g. Health Programs, h. Prevention of Covid-19, i. Handling of Covid-19 (SE No. 443/5283 of 2021), j. Signs, k. Consultation with experts related to Construction Safety, l. Miscellaneous Related to K3 Risk Control, m. Industrial Hygiene, Environmental Management and Monitoring and n. General and Operational (Article 20 of the Pu Regulation Number: 05/PRT/M/2014)

Hazard Identification, Risk Assessment, Priority Scale, K3 Risk Control (Appendix to Pu Regulation Number: 05/PRT/M/2014).

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