E-ISSN : 2963-4946
Vol. 3 No. February 05, 2025

Asian Journal of
Social and Humanities
https://ajosh.org/

Mitigation of Occupational Health Safety and Environmental Risk in Construction Projects on The North Coast of Java

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KEYWORDS
Occupational Health Safety and Environment (K3L), Construction Project, SPSS, Analytical Hierarchy Process (AHP)

ABSTRACT

In Indonesia, the construction industry sector in the last three years has grown rapidly with increasing infrastructure development in Indonesia. This must be supported by the availability of competent human resources and good supervision of workers. This research focuses on mitigating K3L risks in coastal development projects, where complex environmental factors and operational hazards increase the potential for accidents and environmental damage. The method used in this study is a survey method combined with a research study approach. Data collection was carried out using questionnaires distributed to 30 respondents involved in construction projects along the North Coast of Java. The collected data was analyzed using the Statistical Package for the Social Sciences (SPSS) and the Analytical Hierarchy Process (AHP) to identify, measure, and prioritize risks. SPSS was employed to test data reliability, validity, correlation, and regression, while AHP helped determine risk rankings and the consistency of the assessment. The results reveal that environmental factors pose the highest risk (0.67), followed by equipment (0.26) and human factors (0.07). The study highlights the importance of integrating comprehensive K3L strategies to minimize risks and improve project efficiency. This research offers a structured framework for construction companies to implement more effective safety measures, contributing to safer working environments and more sustainable coastal infrastructure development.

Introduction

In Indonesia, the construction industry sector in the last three years has grown rapidly with the increasing infrastructure development in Indonesia, this must be supported by the availability of competent human resources and good supervision of workers. The number of work accidents in the construction sector is the highest compared to work accidents in other fields (Palupi et al., 2018). It is necessary for workers to understand Occupational Safety and Health (OSH) in their work, especially in infrastructure development and with the existence of Risk Management is a planned action carried out by risk owners to reduce the effects of circumstances that increase the likelihood of danger. (Kusumah et al., 2022).

The development of infrastructure development in Indonesia is very rapid, so the importance of the role of controlling the risk of work accidents is becoming increasingly important. However, the implementation of Occupational Health and Environmental Safety (K3L) in general is still often overlooked. This is shown by the high number of work accidents that occur. Based on data from BPKS Ketenagakerjaan, the number of JKK claims in 2019 was recorded as many as 182,835 cases. Furthermore, the number of JKK claims has consistently increased, 221,740 claims in 2020 and 234,370 claims in 2021. Then in 2022, the number rose again to 297,725 claims. Throughout January - November 2023, the number of work accident cases that submitted JKK claims has reached 360,635 cases.(Pangkey et al., 2023)

Occupational Health and Environmental Safety (K3L) is actually a very important thing to pay attention to in every aspect of daily activities. If one aspect is ignored, then an activity will tend to experience risk consequences which of course will be very detrimental, both for the owner of the place of activity, the perpetrator of the activity, and the user of theof the activity. Occupational safety and health in the construction world are regulated in Law No. 2 of 2017 which discusses security, safety, health, and sustainability standards that must be met by service users and service providers. Meanwhile, the implementation system is regulated in government regulation No. 50 of 2012.(Tangdipayuk et al., 2022).

Risk management is a process of identifying, measuring, and forming strategies to manage it through existing resources (Hairul, 2020) while risk mitigation is an effort to reduce and maintain the amount of the main risk to the bottom line so that the risks posed and occurring are very small. The objectives of the research to find out the factors that have the greatest influence on Occupational Safety and Health (K3) in the North Java coastal building project.

The complexity of construction projects, particularly in coastal areas like the North Coast of Java, introduces unique challenges related to Occupational Health Safety and Environmental (K3L) risks. The proximity to marine ecosystems, unpredictable weather conditions, and the use of heavy machinery in fragile environments increase the likelihood of accidents and environmental degradation. These challenges necessitate a robust risk mitigation framework that not only focuses on worker safety but also considers environmental sustainability. Understanding the specific hazards present in coastal construction sites is crucial for developing effective preventive strategies.

Moreover, the increasing demand for infrastructure along the North Coast of Java has accelerated project timelines, often leading to compromised safety standards. Construction companies, driven by tight deadlines and budget constraints, may overlook critical safety protocols, leading to higher incidents of workplace accidents. The high frequency of reported injuries and environmental violations highlights a systemic gap in current risk management practices. Therefore, it becomes imperative to integrate comprehensive K3L measures into every phase of construction, from planning to execution.

Technological advancements provide new opportunities to enhance risk management in construction projects. The use of Building Information Modeling (BIM), drones for site inspections, and advanced data analytics can significantly improve hazard identification and monitoring. However, the adoption of these technologies remains limited in many Indonesian construction projects due to high costs and a lack of technical expertise. Bridging this technological gap is essential for creating safer and more efficient construction practices, especially in complex environments like coastal regions.

Stakeholder involvement is another critical aspect of successful K3L implementation. Collaboration between government agencies, construction firms, local communities, and environmental organizations can lead to more holistic risk mitigation strategies. Regulatory bodies must enforce stringent safety standards, while construction companies need to prioritize worker training and environmental protection. Community engagement also plays a role, as local knowledge can provide valuable insights into environmental risks and culturally appropriate safety practices.

Lastly, continuous evaluation and improvement of K3L practices are vital for adapting to evolving project demands and emerging risks. Implementing feedback loops, conducting regular audits, and promoting a culture of safety within construction teams can help sustain high safety standards. This study aims to identify the key factors influencing K3L in coastal construction projects and propose practical mitigation strategies, contributing to safer work environments and more sustainable development along the North Coast of Java.

The urgency of this research lies in the increasing number of work-related accidents in the construction sector, particularly in coastal areas like the North Coast of Java. As Indonesia pushes for rapid infrastructure development, the focus on Occupational Health Safety and Environmental (K3L) management often takes a back seat. This has resulted in a concerning rise in workplace accidents and environmental damage, with the latest data showing over 360,000 work accident claims in 2023 alone. If left unaddressed, these issues not only threaten worker safety but also risk causing long-term environmental harm, undermining the sustainability of development projects.

Several studies have explored the application of risk management in construction projects. Kusumah et al. (2022) examined the use of Risk Assessment methods to mitigate risks in bridge construction projects in Sukabumi, identifying key factors that increase accident probability and offering strategic solutions for risk reduction. Similarly, Palupi et al. (2018) analyzed occupational safety and health risks in road construction projects in Yogyakarta, finding that a lack of comprehensive safety protocols and inadequate worker training significantly contributed to the high accident rates.

Another study by Butarbutar et al. (2023) applied the Analytical Hierarchy Process (AHP) to identify hazard aspects in hospital construction projects in Jakarta, demonstrating the effectiveness of AHP in ranking and prioritizing risks. Meanwhile, Wiwoho (2020) highlighted the benefits of AHP in evaluating workplace accident risks in general construction projects, suggesting that the method provides a structured approach to decision-making in safety management. However, while these studies offer valuable insights, they often focus on urban or land-based construction projects, leaving a research gap concerning coastal construction environments.

Although previous studies have extensively covered K3L management in urban and land-based construction projects, limited research addresses the unique risks present in coastal construction sites. Coastal projects face distinct challenges, such as exposure to marine ecosystems, fluctuating weather conditions, and increased environmental sensitivity. This gap in research highlights the need for tailored risk mitigation strategies that consider both occupational safety and environmental protection in coastal settings like the North Coast of Java.

This research introduces a novel approach by combining SPSS statistical analysis with the Analytical Hierarchy Process (AHP) to assess and prioritize K3L risks specifically in coastal construction projects. Unlike previous studies that focused primarily on human and equipment risks, this study places equal emphasis on environmental hazards, recognizing their significant impact on both project sustainability and worker safety. The integration of these two analytical methods offers a more comprehensive risk assessment model, contributing new insights to the field of construction safety management.

The primary objective of this research is to identify and analyze the factors that most significantly impact Occupational Health Safety and Environmental (K3L) risks in coastal construction projects on the North Coast of Java. By utilizing SPSS and AHP, the study aims to provide a structured framework for risk prioritization, enabling construction companies to implement more effective safety protocols. The findings are expected to benefit industry stakeholders by reducing workplace accidents, minimizing environmental damage, and promoting more sustainable construction practices in coastal areas.

Research Methods

The method used is a survey method and research study where in collecting data a research instrument is used in the form of a questionnaire which is then analysed with SPSS, and Analytical Hierarchy Process (AHP).

Results and Discussions

Analysis Results of Statistical Package Social Sciences (SPSS)

Descriptive Statistics

Descriptive statistics are used to analyze data by describing or describing the data that has been collected. The following are the results of the descriptive analysis.

Table 1 Descriptive Statistics Results X1

		X1.1	X1.2	X1.3	X1.4	X1.5	X1.6	X1.7	X1.8
N	**Valid**	30	30	30	30	30	30	30	29
	Missing	0	0	0	0	0	0	0	1
Mean		2.03	1.80	2.17	2.47	2.43	2.57	2.23	2.55
Median		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mode		1[a]	2	2	2	2	2	1	2
Std. Deviation		1.066	0.805	0.834	1.106	1.194	1.331	1.165	1.502

Table 2 Statistics Descriptive Results X1 (Continued)

		X1.9	X1.10	X1.11	X1.12	X1.13	X1.14	X1.15
N	**Valid**	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0
Mean		2.70	2.60	2.63	2.40	3.33	2.10	2.57
Median		2.00	2.00	2.00	2.00	3.00	2.00	2.00
Mode		2	1	2	2	2[a]	1[a]	2
Std. Deviation		1.317	1.868	1.650	1.221	1.422	1.155	1.960

Table 3 Hasil Statistics Descriptive X2

		X2.1	X2.2	X2.3	X2.4	X2.5	X2.6	X2.7	X2.8
N	**Valid**	30	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0	0
Mean		1.57	1.60	1.57	2.53	1.37	1.53	1.60	1.60
Median		1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00
Mode		1	1	1	3	1	1	1	1
Std. Deviation		0.971	0.724	0.898	0.973	0.669	0.900	1.003	1.037

Table 4 Statistics Descriptive Results X2 (Continued)

		X2.9	X2.10	X2.11	X2.12	X2.13	X2.14	X2.15	X2.16
N	**Valid**	30	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0	0
Mean		1.67	1.93	1.63	1.47	1.53	1.57	1.53	1.77
Median		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mode		1	1	1	1	1	1	1	1
Std. Deviation		0.959	1.202	0.928	0.937	0.900	0.817	0.937	1.278

Table 5 Statistics Descriptive Results X2 (Continued)

		X2.17	X2.18	X2.19	X2.20	X2.21	X2.22	X2.23	X2.24
N	**Valid**	30	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0	0
Mean		1.53	1.60	1.70	1.63	1.43	1.53	1.37	1.33
Median		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mode		1	1	1	1	1	1	1	1
Std. Deviation		1.042	1.003	0.952	0.928	0.858	0.860	0.718	0.844

Table 6 Statistics Descriptive Results X2 (Continued)

		X2.25	X2.26	X2.27
N	**Valid**	30	30	30
	Missing	0	0	0
Mean		1.47	1.77	1.63
Median		1.00	1.00	1.00
Mode		1	1	1
Std. Deviation		0.937	1.194	0.964

Table 7 Hasil Statistics Descriptive Y

		Y1	Y2	Y3	Y4	Y5	Y6	Y7
N	**Valid**	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0
Mean		2.10	2.43	2.50	3.27	2.27	1.77	7.27
Median		2.00	2.00	2.00	3.00	2.00	2.00	7.00
Mode		1	1	2^a	3	1	1	6
Std. Deviation		1.348	1.832	1.253	1.258	1.363	0.817	1.818

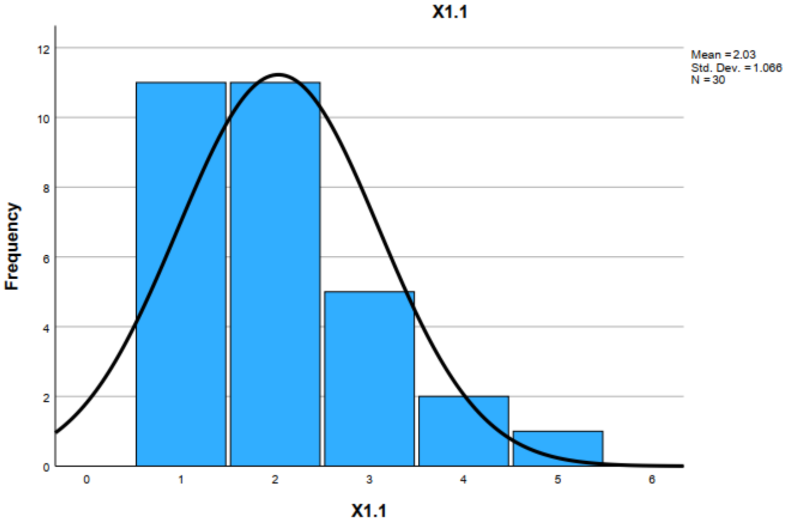


Figure 1 Histogram (X1.1)

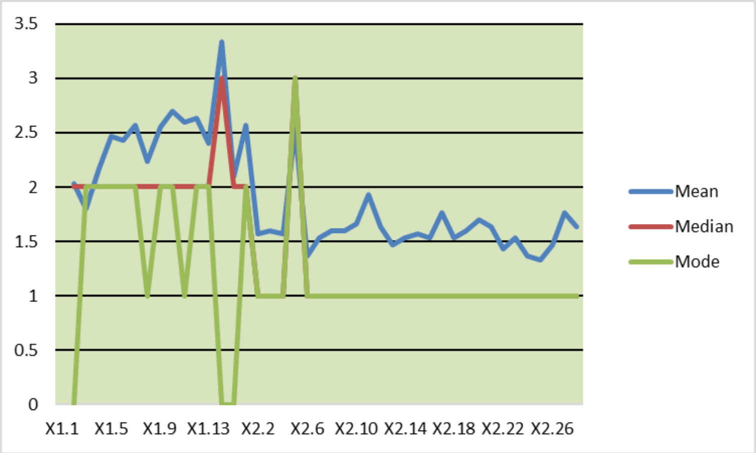


Figure 2 Graph of Mean, Median, and Variable Data Distribution Mode X1 and X2

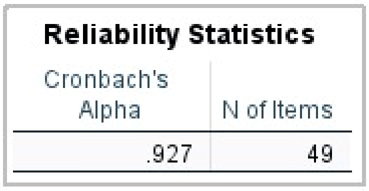
The graph above shows the distribution of mean, median, and mode values of the 42 X variables. Thus, the median value that often appears is 1 and the value of the mode that appears frequently is 1, with the largest mode value is 3 and the lowest is 1.

Reliability Test and Data Validity Test

Reliability Test

The reliability test aims to see if the questionnaire has consistency if the measurement is carried out repeatedly, the questionnaire is declared reliable if the Cronbach Alpha value > 0.6. The variables used in the reality test are those that have passed the validity test.

Table 8 Reliability Statistics



Reliability Statistics

Cronbach's Alpha	N of Items
.927	49

Validity Test

Validity tests are used to determine the validity or suitability of questionnaire data. The R-value in the total statistics item table must be greater than the R-value of the table.

By taking a significance level value of 5% with the number of respondents 30, the significance level value was obtained at 0.361.

The following is a table of validation analysis using SPSS:

Table 9 Item Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
X1.1	100.21	708.027	0.355	0.926
X1.2	100.45	725.613	0.077	0.928
X1.3	100.07	734.067	-0.111	0.929
X1.4	99.72	726.207	0.039	0.929
X1.5	99.83	716.791	0.176	0.928
X1.6	99.69	702.865	0.349	0.927
X1.7	100.00	713.786	0.229	0.927
X1.8	99.69	710.722	0.209	0.928
X1.9	99.48	754.116	-0.366	0.933
X1.10	99.59	674.537	0.530	0.925
X1.11	99.55	697.542	0.338	0.927
X1.12	99.86	712.837	0.232	0.928
X1.13	98.97	730.677	-0.039	0.930
X1.14	100.17	693.005	0.577	0.925
X1.15	99.66	690.591	0.336	0.928
X2.1	100.66	684.805	0.854	0.923
X2.2	100.66	702.663	0.682	0.925
X2.3	100.66	695.020	0.708	0.924
X2.4	99.69	689.365	0.761	0.923
X2.5	100.86	701.409	0.776	0.924
X2.6	100.69	694.079	0.726	0.924
X2.7	100.62	691.030	0.705	0.924
X2.8	100.62	690.244	0.695	0.924
X2.9	100.55	688.470	0.793	0.923
X2.10	100.28	676.850	0.816	0.922

Table 10 Total Item Statistics (Lanjutan)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
X2.11	100.59	689.751	0.794	0.923
X2.12	100.76	693.475	0.706	0.924
X2.13	100.69	695.222	0.701	0.924
X2.14	100.66	696.948	0.736	0.924
X2.15	100.69	692.079	0.736	0.924
X2.16	100.45	675.970	0.775	0.923
X2.17	100.69	680.293	0.877	0.922
X2.18	100.62	688.030	0.763	0.923
X2.19	100.52	686.544	0.840	0.923
X2.20	100.59	692.037	0.746	0.924
X2.21	100.79	699.384	0.642	0.925
X2.22	100.69	690.079	0.850	0.923
X2.23	100.86	707.123	0.569	0.925
X2.24	100.90	699.453	0.651	0.925
X2.25	100.76	695.904	0.656	0.924
X2.26	100.45	676.399	0.826	0.922
X2.27	100.59	698.608	0.585	0.925
Y1.1	100.17	713.791	0.193	0.928
Y1.2	99.83	714.576	0.117	0.931
Y1.3	99.76	724.333	0.055	0.929
Y1.4	98.93	719.352	0.130	0.928
Y1.5	99.97	687.534	0.554	0.925
Y1.6	100.45	714.970	0.321	0.927
Y1.7	95.00	725.214	0.011	0.932

From tables 9 and 10, it can be concluded that if the corrected item-total correlation value is greater than the Rtable, it is declared valid.

The following are the results of the validity test:

Table 11 Validity Test Results

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
X1.10	99.59	674.537	0.530	0.925
X1.14	100.17	693.005	0.577	0.925
X2.1	100.66	684.805	0.854	0.923
X2.2	100.66	702.663	0.682	0.925
X2.3	100.66	695.020	0.708	0.924
X2.4	99.69	689.365	0.761	0.923
X2.5	100.86	701.409	0.776	0.924
X2.6	100.69	694.079	0.726	0.924
X2.7	100.62	691.030	0.705	0.924
X2.8	100.62	690.244	0.695	0.924
X2.9	100.55	688.470	0.793	0.923
X2.10	100.28	676.850	0.816	0.922
X2.11	100.59	689.751	0.794	0.923
X2.12	100.76	693.475	0.706	0.924
X2.13	100.69	695.222	0.701	0.924
X2.14	100.66	696.948	0.736	0.924
X2.15	100.69	692.079	0.736	0.924
X2.16	100.45	675.970	0.775	0.923
X2.17	100.69	680.293	0.877	0.922
X2.18	100.62	688.030	0.763	0.923
X2.19	100.52	686.544	0.840	0.923
X2.20	100.59	692.037	0.746	0.924
X2.21	100.79	699.384	0.642	0.925
X2.22	100.69	690.079	0.850	0.923
X2.23	100.86	707.123	0.569	0.925
X2.24	100.90	699.453	0.651	0.925
X2.25	100.76	695.904	0.656	0.924
X2.26	100.45	676.399	0.826	0.922
X2.27	100.59	698.608	0.585	0.925
Y1.5	99.97	687.534	0.554	0.925

Correlation Analysis

Correlation analysis aims to determine the level of closeness of the relationship between variables expressed by the correlation coefficient (r). The types of variables X and Y can be positive or negative.

1. Decision-making Requirements

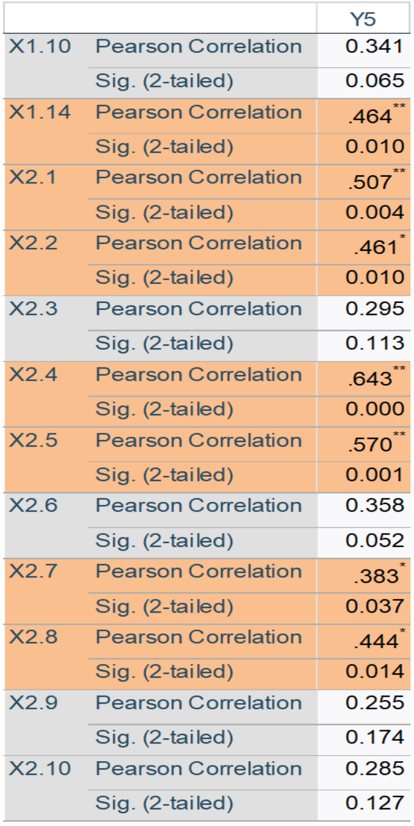
- If the significance value < 0.05 → **is valid**
- If a significance value > 0.05 → **is invalid**

2. Relationship Degree Guidelines

- Pearson Correlation value 0.00 to 0.20 → is not correlated
- Pearson Correlation value 0.21 to 0.40 → weak correlation
- Pearson Correlation value 0.41 to 0.60 → moderate correlation
- Pearson Correlation value 0.61 to 0.80 → strong correlation
- Pearson Correlation values of 0.81 to 1.00 → are highly correlated

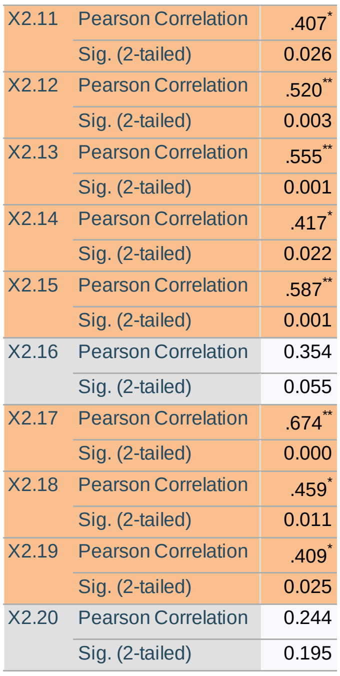
The following are the results of the correlation analysis between X and Y.

Table 12 Correlation X and Y results



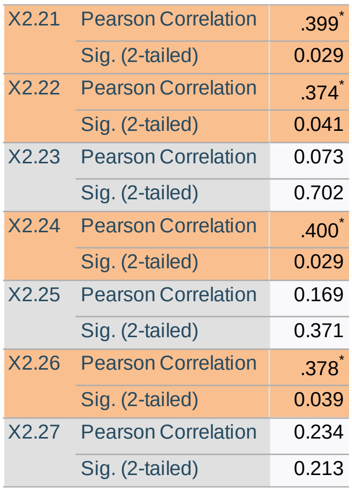
		Y5
X1.10	Pearson Correlation	0.341
	Sig. (2-tailed)	0.065
X1.14	Pearson Correlation	$.464^{**}$
	Sig. (2-tailed)	0.010
X2.1	Pearson Correlation	$.507^{**}$
	Sig. (2-tailed)	0.004
X2.2	Pearson Correlation	$.461^{*}$
	Sig. (2-tailed)	0.010
X2.3	Pearson Correlation	0.295
	Sig. (2-tailed)	0.113
X2.4	Pearson Correlation	$.643^{**}$
	Sig. (2-tailed)	0.000
X2.5	Pearson Correlation	$.570^{**}$
	Sig. (2-tailed)	0.001
X2.6	Pearson Correlation	0.358
	Sig. (2-tailed)	0.052
X2.7	Pearson Correlation	$.383^{*}$
	Sig. (2-tailed)	0.037
X2.8	Pearson Correlation	$.444^{*}$
	Sig. (2-tailed)	0.014
X2.9	Pearson Correlation	0.255
	Sig. (2-tailed)	0.174
X2.10	Pearson Correlation	0.285
	Sig. (2-tailed)	0.127

Table 13 Correlation X and Y Results (Continued)



X2.11	Pearson Correlation	$.407^{*}$
	Sig. (2-tailed)	0.026
X2.12	Pearson Correlation	$.520^{**}$
	Sig. (2-tailed)	0.003
X2.13	Pearson Correlation	$.555^{**}$
	Sig. (2-tailed)	0.001
X2.14	Pearson Correlation	$.417^{*}$
	Sig. (2-tailed)	0.022
X2.15	Pearson Correlation	$.587^{**}$
	Sig. (2-tailed)	0.001
X2.16	Pearson Correlation	0.354
	Sig. (2-tailed)	0.055
X2.17	Pearson Correlation	$.674^{**}$
	Sig. (2-tailed)	0.000
X2.18	Pearson Correlation	$.459^{*}$
	Sig. (2-tailed)	0.011
X2.19	Pearson Correlation	$.409^{*}$
	Sig. (2-tailed)	0.025
X2.20	Pearson Correlation	0.244
	Sig. (2-tailed)	0.195

Table 14 Correlation X and Y Results (Continued)

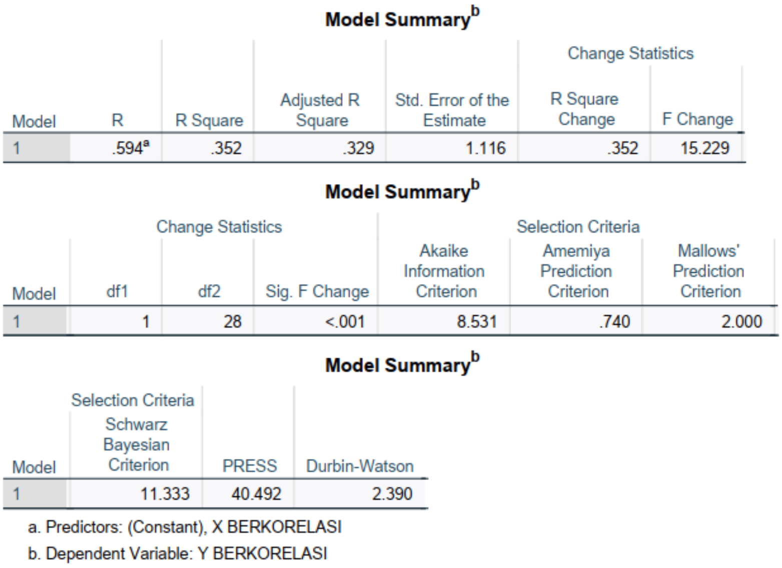


X2.21	Pearson Correlation	.399*
	Sig. (2-tailed)	0.029
X2.22	Pearson Correlation	.374*
	Sig. (2-tailed)	0.041
X2.23	Pearson Correlation	0.073
	Sig. (2-tailed)	0.702
X2.24	Pearson Correlation	.400*
	Sig. (2-tailed)	0.029
X2.25	Pearson Correlation	0.169
	Sig. (2-tailed)	0.371
X2.26	Pearson Correlation	.378*
	Sig. (2-tailed)	0.039
X2.27	Pearson Correlation	0.234
	Sig. (2-tailed)	0.213

Regression

After the correlated variables are known, the correlated variables are used for the next analysis, namely regression analysis. Regression analysis aims to determine the direction of the relationship between independent variables and dependent variables, whether each independent variable is positive or negative, and to predict the value of dependent variables, whether the value of independent variables increases or decreases.

Table 15 Model Summary of Regression Test Results of Stepwise Method



Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	.594[a]	.352	.329	1.116	.352	15.229

Model Summary[b]

Model	Change Statistics			Selection Criteria		
	df1	df2	Sig. F Change	Akaike Information Criterion	Amemiya Prediction Criterion	Mallows' Prediction Criterion
1	1	28	<.001	8.531	.740	2.000

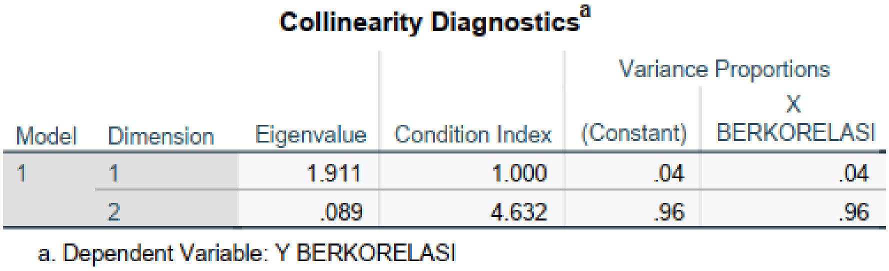
Model Summary[b]

Model	Selection Criteria		
	Schwarz Bayesian Criterion	PRESS	Durbin-Watson
1	11.333	40.492	2.390

a. Predictors: (Constant), X BERKORELASI

b. Dependent Variable: Y BERKORELASI

Table 16 Value Collinearity Diagnostics Metode Stepwise



Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	X BERKORELASI
1	1	1.911	1.000	.04	.04
	2	.089	4.632	.96	.96

a. Dependent Variable: Y BERKORELASI

From these results, an Rsquare value of 0.352 was obtained, which means that it only describes 35.2% of the population. Meanwhile, the collinearity index value is sufficient, namely CI < 17. Because the Rsquare result is less than 80%, it is reduced to the extent that it spreads far from the equation of the formed line. The plot P-P graph obtained from the SPSS point is in a horizontal line, so the data is distributed evenly or normally.

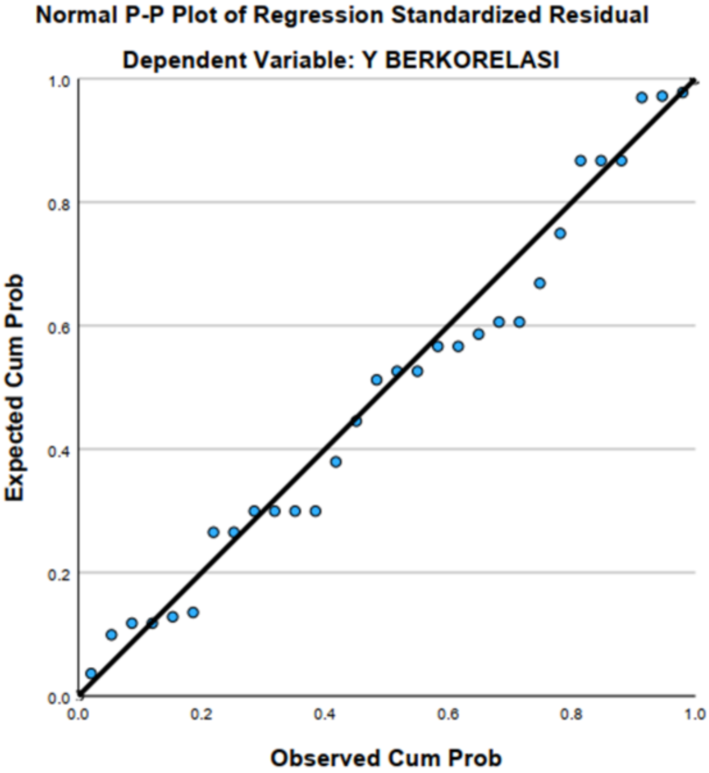


Figure 3 P-P Chart Plot 42 Variables

Metode Analytical Hierarchy Process (AHP)

Calculation analysis with the Analytical Hierarchy Process (AHP) method will be obtained with the final result that knows the Risk Ranking of the questionnaire results that have been processed through the SPSS application. The purpose of this method is to determine the level of danger of the K3L aspect in construction projects.

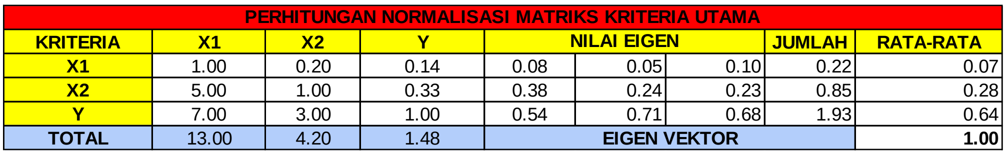
The criteria to support the calculation of the analysis using AHP are variables X1, X2, and Y. The alternatives chosen as factors causing work accidents are humans, equipment, and the environment.

Formula:

CI = ((λmax – n)/ n-1) → CI < 0.1 then **consistent**
CR = CI/CR

Calculation of criteria with a matrix

Table 17 Calculation of Criteria with Matrix



PERHITUNGAN NORMALISASI MATRIKS KRITERIA UTAMA								
KRITERIA	**X1**	**X2**	**Y**	**NILAI EIGEN**			**JUMLAH**	**RATA-RATA**
X1	1.00	0.20	0.14	0.08	0.05	0.10	0.22	0.07
X2	5.00	1.00	0.33	0.38	0.24	0.23	0.85	0.28
Y	7.00	3.00	1.00	0.54	0.71	0.68	1.93	0.64
TOTAL	13.00	4.20	1.48	**EIGEN VEKTOR**				**1.00**

λmax = ((13 x 0.07) + (4.2 x 0.028) + (1.48 x 0.64))
= 3.10

CI = ((λmax – n)/ n-1)
= (3,10 – 3) / 3 – 1)
= 0.05 < 0.1 → **OK**

CR = CI/CR
= 0,05/0,58
= 0,08

Ratio Consistency of 0.08 is less than the tolerance limit of 0.1 or 10%. So, the comparison matrix is said to be consistent. This shows that the research does not need to be repeated or improved.

Alternative Weight Values

After the weight of the criteria is obtained by the AHP method, then the best alternative among the three alternatives of Human, Equipment, and Environment is analyzed with the following stages:

Human

There are three sub-criteria found in the human factor. These three sub-criteria are the factors that cause work accidents in construction projects.

The three factors are Human (X1), Equipment (X2), and Environment (Y). Next, the weight of each sub-criterion is calculated and the following weights are produced.

Table 1 Calculation of Matrix X1 Alternative Normalization

PERHITUNGAN NORMALISASI MATRIKS X1								
X1	MANUSIA	ALAT	LINGKUNGAN	NILAI EIGEN			JUMLAH	RATA-RATA
MANUSIA	1.00	0.25	0.13	0.08	0.06	0.08	0.22	0.07
ALAT	4.00	1.00	0.33	0.31	0.24	0.23	0.77	0.26
LINGKUNGAN	8.00	3.00	1.00	0.62	0.71	0.68	2.01	0.67
TOTAL	13	4.25	1.46	EIGEN VEKTOR				1.00

Equipment

There are three sub-criteria found in the equipment factor. These three sub-criteria are the factors that cause work accidents in construction projects.

The three factors are Human (X1), Equipment (X2), and Environment (Y). Next, the weight of each sub-criterion is calculated and the following weights are produced.

Table 19 X2 Matrix Alternative Normalization Calculation

PERHITUNGAN NORMALISASI MATRIKS X2								
X2	MANUSIA	ALAT	LINGKUNGAN	NILAI EIGEN			JUMLAH	RATA-RATA
MANUSIA	1.00	0.20	0.11	0.08	0.05	0.08	0.20	0.07
ALAT	5.00	1.00	0.50	0.38	0.24	0.34	0.96	0.32
LINGKUNGAN	9.00	2.00	1.00	0.69	0.48	0.68	1.85	0.62
TOTAL	15	3.20	1.61	EIGEN VEKTOR				1.00

Environment

There are three sub-criteria found in the equipment factor. These three sub-criteria are the factors that cause work accidents in construction projects. The three factors are Human (X1), Equipment (X2), and Environment (Y). Next, the weight of each sub-criterion is calculated and the following weights are produced.

Table 20 Calculation of Alternate Normalization of Y Matrix

PERHITUNGAN NORMALISASI MATRIKS Y								
Y	MANUSIA	ALAT	LINGKUNGAN	NILAI EIGEN			JUMLAH	RATA-RATA
MANUSIA	1.00	0.33	0.11	0.08	0.08	0.08	0.23	0.08
ALAT	3.00	1.00	0.33	0.23	0.24	0.23	0.69	0.23
LINGKUNGAN	9.00	3.00	1.00	0.69	0.71	0.68	2.08	0.69
TOTAL	13	4.33	1.44	EIGEN VEKTOR				1.00

Example X1 calculation:

λMax = ((13 x 0,07) + (4,25 x 0,026) + (1,46 x 0,67))
= 3,03

THERE = ((λmaks – n)/ n-1)
= (3,03 – 3) / 3 – 1)
= 0,01 < 0,1 → **OK**

CR = CI/CR
= 0.01/0.58

= 0.02

Risk Ranking

Table 21 Risk Ranking

PERANGKINGAN	
MANUSIA	0.07
ALAT	0.26
LINGKUNGAN	0.67

Example calculation:

From the results of the calculations and outputs that have been made, the next step is to make a risk ranking related to the problems obtained. Which has the highest risk to the work of this project?

Human= **((Average of Criteria x Average of Alternatives)**
= ((0.07 x 0.07) + (0.28 x 0.07) + (0.64 x 0.08))
= 0.07

Equipment = **((Average of Criteria x Average of Alternatives)**
= ((0.07 x 0.26) + (0.28 x 0.23) + (0.64 x 0.32))
= 0.26

Environment = **((Average of Criteria x Average of Alternatives)**
= ((0.07 x 0.67) + (0.28 x 0.62) + (0.64 x 0.69))
= **0,67**

In the results of the risk ranking calculation, the environment that has the highest risk is **the environment with a risk ranking value of 0.67**.

a. The environment has the highest risk value because every work carried out in the field can affect the surrounding environment, such as damage to the marine ecosystem due to being hit by concrete cubes that are dropped to the bottom of the sea level. Damage to the project environment also has an impact on workers such as a decrease in work efficiency which affects the project completion time. To overcome excessive damage to the environment, after the project is completed, replanting or reforesting the coastal part is carried out to create a new ecosystem that can minimize the potential for flooding.

b. Followed by the second highest risk value, namely **the tool with a risk ranking value of 0.26**. Tools have the second highest risk value because tools are often directly exposed to beach water which contains a lot of salt which causes parts of the tool to corrode easily. Damage to equipment can affect worker performance, such as causing equipment to not operate properly it can affect the efficiency of project completion. To overcome damage to the equipment, the company must carry out maintenance on the equipment used in the field every few weeks.

c. Then the last one with the smallest risk value is **humans with a risk ranking value of 0.07.** Humans are ranked last because calculations are carried out through AHP, it turns out that a small value is obtained because humans use tools as a support for project work and the environment as a medium for project creation that causes the smallest risk to be obtained to humans.

The use of PPE and knowledge of K3L in humans is a very important and very useful countermeasure for the safety of workers which will also greatly affect the project completion time.

Conclusion

Based on the analysis of questionnaire data from 30 respondents, it was determined that out of 122 K3L management variables affecting project performance, 73 were discarded after expert validation, leaving 49 variables for respondent distribution. Following data collection and processing, 30 variables passed the validity test, with 19 showing significant correlation in the correlation test. A regression analysis yielded an Rsquare value of 0.352, indicating it explains only 35.2% of the population, and a collinearity index (CI) value below 17, suggesting sufficient collinearity. As the Rsquare was below 80%, a sample reduction was implemented for data points far from the regression line. Additionally, AHP calculations revealed a consistency ratio of 0.08, which is below the 0.1 tolerance limit, indicating a consistent comparison matrix. Thus, it can be concluded that K3L management significantly influences project implementation time.

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