HSE RISK ANALYSIS OF CONSTRUCTION WORKERS USING ENTERPRISE RISK MANAGEMENT METHOD

ANIK RATNANINGSIH, JOJOK WIDODO SOETJIPTO, ANITA TRISIANA, DIAH AYU RESTUTI W, DIMAS AGIL

[1]*Civil Engineering Department, Faculty of Engineering, University of Jember, Jember, East Java, Indonesia*
[*]*Corresponding Author: anik.teknik@unej.ac.id*

ABSTRAK

The rapid growth of the population in an area requires an increase in housing. This is a challenge for sustainable housing construction. One of the responsibilities necessary is the risk management of work accidents in construction. This study aims to determine the identification, assessment, and mitigation actions for the risk of work accidents in housing construction. The data collection process was carried out by distributing questionnaires to housing project workers in Paser Regency, East Kalimantan. Identification of work accident risk is carried out using the HIRA (Hazard Identification and Risk Assessment) method. Assessment of each work accident risk using the ERM (Enterprise Risk Management) Interface method. Mitigation actions on dominant risks are carried out in coordination with the project HSE. The identification results using the HIRA method show that there are 17 risk factors for work accidents. Assessment of each risk using the ERM Interface method resulted in 7 risk factors with low category, eight risk factors with medium category, and two high category risk factors. Some mitigation actions from coordination with HSE on dominant risk factors include installing warning signs in all project areas, conducting routine safety patrols, installing work area safety barriers, and workers using body harnesses/safety belts.

Keywords: Risk; HIRA; ERM; Risk Response

1. INTRODUCTION

East Kalimantan is a province with rapid population growth, with a population that continues to increase every year. In addition, Paser Regency as one of the administrative cities of East Kalimantan is experiencing positive population growth where population growth will increase the need for housing, making housing projects increase rapidly. Housing projects have unique characteristics because they are a series of construction activities carried out in a relatively short time and with limited resources to build infrastructure according to the standards set out in the contract documents. The budget plans and allocations prepared in the contract documents do not have to match what happened during implementation. Therefore, during the implementation phase of construction, service providers face various unforeseen circumstances that present implementation risks (Hidayat & Siswoyo, 2020). According to (Wisudawati & Patradhiani, 2020) As a developer of housing construction projects, I know that the risk of work accidents can occur due to two things: humans who do not comply with work safety and an unsafe environment.

Hazard identification and risk analysis refer to Indonesian Government Regulation No. 10 of 2021 concerning Implementation of the Construction Safety Management System (SMKK). In this regulation, hazard identification and risk analysis are important things that must be done by companies to prevent and reduce workplace injuries and work-related illnesses and create an efficient, comfortable and productive workplace. Hazard recognition and risk evaluation are a form of OHS planning that is used as the basis for preparing OHS programs and policies (Kementerian PUPR, 2021).

There are several hazard risk analysis methods that are often used in various studies, including HIRA, HAZID, and HAZOP. One method that has not been widely used by researchers in construction projects is enterprise risk management. The method of Enterprise Risk Management (ERM) that will be used in this study is a method for determining the optimal strategy for a construction project and ensuring the company's achievements must consider various risk factors, identified risks are controlled and reduced (Iswajuni et al., 2018). According to (Rikaz et al., 2020), (Damayanti & Venusita, 2022), (Kurniawan & Wibowo, 2019) to anticipate risk, disclosure Enterprise Risk Management (ERM) must be implemented properly because, with this disclosure, the contractor can know that the company can manage the company well. To assist in solving this problem, this research uses the HIRA method, which aims to map the potential hazards that occur in each work process (Afnella & Utami, 2021), (Andriani et al., 2022).

Some of the studies that have been conducted by (Pratama et al., 2022), (Tiurma Elita Saragi, 2019), (Ni Kadek Sri Ebtha Yuni et al., 2021), (Magdalena et al., 2022), (Trisiana et al., 2019), (Triase, 2019) has resulted in the success of a project, one of which is influenced by the implementation of an appropriate K3 Management System. This reinforces the need for K3 risk analysis on Housing Construction projects in Paser Regency. These risks are not only dealing with workers to avoid them; work accidents that occur can also have the impact of failure or inaccuracy of project work. This study aims to identify, assess, and determine mitigation actions on K3 risk factors in housing construction projects in Paser Regency.

2. METHODS

2.1. Research Location

The research is located in a housing construction project in Tanjung Pinang Village, Batu Sopang District, Paser Regency, East Kalimantan. The distance is about 222 Km from Balikpapan City.

2.2. Stages of Research

The steps of completing this research include several stages. The first stage is conducting a literature study, which then identifies the problem. This is followed by data collection in the form of primary and secondary data containing data from questionnaires, organizational structure, and JSA on the project. Then, the risk variables of the project will be determined. Continue the preparation of preliminary questionnaires and determine which respondents will distribute the questionnaires. The results of the preliminary questionnaire were tested for validity and reliability. Risk factor variables that passed the validity and reliability tests continued for the dissemination of the main questionnaire. The results of the main questionnaire continued with a hazard identification analysis using the HIRA method and then a hazard risk assessment analysis using the ERM method. Then, the output of this study, namely from selected dominant risk factors, is handled in coordination with HSE.

2.3. HIRA Method

HIRA (Hazard Identification and Risk Assessment) is a method or technique for identifying potential hazards in the workplace by defining the characteristics of potential hazards and assessing emerging risks through risk assessment using a risk assessment matrix. Risk analysis in risk management is a useful process for evaluating the impact and likelihood of identified risks. This process is done by combining risks based on their impact on project objectives. For rating scales used on Australian Standard/New Zealand Standard (AS/NZS).

Each value that can be categorized as sourced from AS/NZS Standard 4360 is as follows:

E : Extreme Risk (A category where risk cannot be tolerated, so it needs to be handled as soon as possible by management)

H : High Risk (A category of risk that should not be desired, which can only be faced if minimizing risk is not done, which then needs direct handling from management)

M : Moderate Risk (A category in which a risk can be faced despite requiring clear responsibilities from management)

L : Low Risk (Category of risk that can be accepted and overcome using routine procedures in management).

2.4. ERM Method

Enterprise Risk Management is a method or strategy by which companies in all industries assess, manage, operate, finance, and control risk from all sources with the aim of increasing short-term and long-term business value (Casualty Actuarial Society, 2003). Various experts define ERM as a strategy prepared by management that specifically discusses steps to overcome potentially risky activities in order to obtain the goals of the company.

Intersecting with the process of risk management, the COSO ERM Integrated Framework has compiled several elements that must be integrated between the four control components in the ERM method, namely:

1. Internal Environment

   Risk management carried out by the company is one form of risk management that occurs in the company's internal environment. This has implications for the form of acceptable risk level (risk appetite), risk tolerance, risk culture, and implementation of the ERM method.

2. Event Identification

   For all events, both within and external to the company, that have the potential to affect the achievement of objectives, various possible risks must be identified.

3. Risk Assessment

   In risk assessment, the company evaluates changes in the size and magnitude of risks that may affect the achievement of company goals. These risks can be determined based on the likelihood of occurrence and impact, so mitigation can be calculated from highest to lowest based on the level and magnitude of risk.

4. Risk Response

   In the next step, appropriate risk handling is carried out for each risk that occurs, the level of risk tolerance is determined, and various options are compiled to eliminate the identified risks.

2.5. Data Analysis Test

It can be said that testing of variables in this study can be really valid, it is necessary to test validity using statistical tools. Pearson Bivariate Correlation (Pearson Moment Product) is used in the validation process. This analysis is calculated by correlating the score of each item with the total score achieved. The correlation formula used by Pearson Bivariate is listed in the equation below:

$$r = \frac{n\,(\sum XY) - (\sum X \sum Y)}{\sqrt{(n\sum X^2 - \sum X^2)(n\sum Y^2) - (\sum Y)^2}} \quad (1)$$

With captions:
r = Correlation coefficient
X = Question score
Y = Total score
N = Number of samples

The reliability test in this study is used to determine the level of reliability of data produced by the instrument to ensure the unity of the research instrument in the same concept. Measurement results can be said to be reliable if the measurement results are used twice to measure the same symptoms and the values obtained are relatively consistent. The reliability test in this study used a statistical aid program using the Alpha Chronbach formula because this study was in the form of questionnaires and stratified scales. Cronbach's Alpha formula is like the following equation below:

$$ri = \left[\frac{k}{(k-1)}\right]\left[1 - \frac{\sum\sigma_b^2}{\sigma_b^2}\right] \quad (2)$$

With captions:
r = Reliability Value
$\sum\sigma_b^2$ = Number of score variances per question item
σ_t^2 = Total variance
k = Number of question items

3. RESULTS AND DISCUSSION

3.1. Results of Preliminary and Main Questionnaires

The analysis of preliminary questionnaire data results is useful as a follow-up identification of the main questionnaire design and confirmation of potential hazard risk variables in the field for respondents. Respondents provide answers to selected questions with answers "Possible" and "Unlikely to Happen" to each potential risk that has been provided. Results of the percentage of respondents who answered "May Happen" and "Unlikely to Happen" using Microsoft Excel auxiliary programs. The relevant variable answers are in **Table 3.1** below:

Table 3. 1 Example of Relevant Variable Value Calculation Results

Code	Job Details	Potential Risks	Risk Percentage		Information
			Possible	Impossible	
X1	Material Placement Management	Workers were injured by being hit by materials	77,78%	22,22%	Relevant
X3		Workers have accidents due to mobilization	77,78%	22,22%	Relevant

From the results of Table 4.2 data above, it is known that there are 18 "relevant" potential hazard variables from 26 variables.

The next stage is a validation test on the remaining 18 relevant variables from 26 variables. In this study using R Table 18 respondents and using 5% level of significance with df used is 18 of 0,468. Example of validation calculation on Workers injured due to being hit by material:

$$r = \frac{n\,(\sum XY) - (\sum X \sum Y)}{\sqrt{(n\sum X^2 - \sum X^2)(n\sum Y^2) - (\sum Y)^2}} = \frac{18(264) - (14 \times 303)}{\sqrt{(18 \times 14 - (14)^2)(18 \times 5647) - (303)^2}}$$

$$r = \frac{4752 - 4242}{\sqrt{(252 - 196)(101646 - 91809)}} = \frac{510}{742{,}2} = 0{,}687 > 0{,}468\ (Valid)$$

Table examples of calculating the value of valid variable coefficients are listed in **Table 3. 2** below:

Tabel 3. 2 Example of Calculating the Value of a Valid Variable Coefficient

Code	Job List	Potential Risks	R Count	R Table	Information
X1	Material Placement Management	Workers were injured by being hit by materials	0,687	0,468	Valid
X3		Workers have accidents due to mobilization	0,662	0,468	Valid

Table 3. 2 is the result of the validity test calculation; from these calculations, 17 risk variables are considered "valid" from 26 existing risk variables.

The next step is to carry out a reliability test. The reliability test calculation in this test uses internal consistency with Cronbach Alpha. According to Nunnally in Streiner, 2003), test data is declared reliable if it has a Cronbach Alpha reliability coefficient of more than 0.70 (ri > 0.70).

$$ri = \left[\frac{k}{(k-1)}\right]\left[1 - \frac{\sum\sigma_b^2}{\sigma_b^2}\right]\ r = \left[\frac{18}{(18-1)}\right]\left[1 - \frac{2{,}803}{19{,}908}\right] = 0{,}9$$

Table 3. 3 Reliability Test Table

Decision		
Set Value	**Cronbach Alpha's Value**	**Information**
0,7	0,9	Reliable

Based on **Table 3. 3** reliability values (Cronbach Alpha) are 0.9 so this test is reliable.

In this study, the risk assessment was calculated after distributing the main questionnaire to 15 respondents. All respondents must answer by choosing a number value from 1 to 5 in each column of likelihood (likelihood) and severity (severity) in each variable asked. The obtained values are then matched using a risk rating table. Risk assessment using the HIRA method can be used to obtain the value and risk category of each variable. The risk value is calculated from the multiplication between likelihood (likelyhood) and severity (severity) which is used to determine the value of the existing risk. The calculation formula and calculation examples in **Table 3. 4** are:

$$average\ risk\ score = \frac{Total\ risk\ scores\ of\ all\ respondents}{Number\ of\ respondents}$$

Table 3. 4 Risk Value Calculation

Risks Variable	∑ Value (L×S)	Value (L×S)/n	Risks Matrix
Workers were injured by being hit by materials	59	4	Low
Workers have accidents due to mobilization	158	11	High

From the calculation example in the table, risk values of 4 and 11 are obtained which are then matched with the risk rating matrix table and obtained Low and High risk types.

3.3. *Interface* ERM

Before identifying the existing risks, the contractor first describes the problems that have occurred on the project side along with the ways of handling and prevention that have been done. Internal factors influence the occurrence of problems, namely factors in the working method in the field. After identifying the problems that exist in the project, the risks that occur should be identified. The following is an analysis of the risk identification that occurs:

Table 3. 5 *Interface* ERM

No	Job List	Potential Risks	Risk Assessment			Information
			Probability	Severity	Risk Value	
1	Material Placement Management	Workers were injured by being hit by materials	2,5	1,6	4	Probability 1 = Almost never 2 = Rare 3 = May occur occasionally 4 = Frequent occurrence 5 = May occur frequently Severity 1 = No injuries (little financial loss) 2 = Minor injuries (moderate financial loss) 3 = Moderate injuries (need
2		Workers have accidents due to mobilization	2,5	4,3	11	
3	Human traffic management and safety	Worker falls, minor injuries from slipping	2,8	1,6	4	
4		Workers hit hard objects / hit by materials	2,3	1,8	4	
5		Worker impaled by sharp object, sliced by zinc	2,3	2,5	6	
6	Machine Mobilization Demobilization Work	Workers have traffic accidents	2,5	4,1	10	
7	Preparatory Work	Workers stepped on sharp objects and scratched sharp objects	1,4	2,4	3	

No	Job List	Potential Risks	Risk Assessment			Information
			Probability	Severity	Risk Value	
8		The worker's head stricken by object	1,4	3,4	5	medical attention, major losses) 4 = Severe injuries > 1 person (heavy losses, production interruptions) 5 = Fatal > 1 person (very large loss, cessation of all activities) Risk Level 1 – 4 = Low 4 – 9 = Medium 9 – 16 = High 16 – 25 = Extreme
9		Workers stumble and fall	1,6	1,9	3	
10		Worker slip	1,8	1,7	3	
11	Earthworks	Workers experience shortness of breath due to inhalation of dust	1,9	1,6	3	
12	Masonry works	The worker's head was hit by a stone	2	4,1	8	
13	Concrete Works	The worker's head stricken by object	2,3	3,5	8	
14		The worker's leg was pierced by a nail	2,2	2,9	6	
15	Structural, Architectural and Finishing Works	Workers stepping on sharp objects	3,9	1,5	6	
16		Workers stumble and fall	4,3	1,6	7	
17		Workers are hit by blunt and sharp objects	2,3	3,5	8	

After identifying and assessing the existing risks, the next stage is to provide a risk response to the most dominant risk in coordination with the HSE; the dominant risk is obtained using the Pareto diagram method.

3.4. Risk Mitigation Operation

A risk mitigation operation is a prevention effort to reduce the impact of a risk event. The formulation of mitigation actions is focused on 11 variables that cause events that have received priority on the Pareto diagram. The most high-risk jobs that are loaded have intensive handling, both in terms of impact, frequency of events, and difficulty failures to detect. Handling of these risks is obtained through coordination with the head or member of HSE at the location of the case study.

Table 3. 6 Examples of Risk Mitigation Operation

Code	Job List	Failure Mode	Risk Mitigation
X3	Material Placement Management	Workers suffer accidents due to the mobilization of material placement	1. Install warning signs in each work area for the mobilization of material placement 2. Conduct a safety talk/safety morning by the HSE. 3. More approaches and explanations are carried out in order to follow safe work procedures 4. Conduct routine safety patrols
X9	Heavy Equipment Mobilization Demobilization Work	Workers have traffic accidents due to heavy equipment mobilization demobilization work	1. Installation of clear signs for the scope of the operating heavy equipment area 2. Coordination with project K3 officers with work activities 3. Routine safety patrols are carried out 4. More approaches and explanations are carried out in order to follow safe work procedures
X19	Masonry Work	Worker head hit by rock due to masonry work	1. Install a safety net so that it is safe in the lower area 2. Overcome by taking it to the nearest hospital to get help so that workers are saved 3. Installed clear warning signs when there is work at the top, install safety in the workplace, provide protection for objects falling from above 4. Conduct routine safety patrols 5. Efforts are made for equipment to be tied above so that if it falls it is still hanging and a safety net and warning signs are installed

In the table above, several actions must be taken for the dominant risks obtained from the Pareto chart.

4. CONCLUSION

The results of OHS risk identification obtained as many as 26 risk variables. After validity and reliability tests, 17 risk variables were identified. For example, workers have accidents due to mobilization of material placement, and workers' heads are hit by stones on partner work. From the results of the analysis of the risk level assessment matrix on each work accident risk variable using a comparison of probability impact calculations, seven risk factors with low levels, eight risk factors at medium levels, and two risk factors with high levels were obtained. 11 dominant risks were obtained from 17 variables identified using Pareto chart calculations, each with different mitigation actions. Mitigation actions taken include installing warning signs in all project areas, conducting routine safety patrols, installing work area safety barriers, and workers are required to use body harness / safety belts, placing signs or safety lines in the work area, and providing warning signs in the area.

BIBLIOGRAPHY

Afnella, W., & Utami, T. N. (2021). *Analisis Risiko Kecelakaan Kerja Metode Hira (Hazard Identification and Risk Assessment) Di Pt. X*. PREPOTIF: Jurnal Kesehatan Masyarakat, 5(2), 1104–1012.

Andriani, D., Ratnaningsih, A., & Putra, P. P. (2022). Analisis HIRARC Risiko K3 Fabrikasi dan Erection Gedung Baja Pembangunan Hotel Loji Kridanggo Boyolali. RekaRacana: Jurnal Teknil Sipil, 8(2), 70.

Damayanti, A. I., & Venusita, L. (2022). Pengaruh Pengungkapan Enterprise Risk Management (ERM) terhadap Kinerja Perusahaan pada Perusahaan Manufaktur yang Terdaftar di Bursa Efek Indonesia (BEI). Jurnal Akuntansi AKUNESA, 10(3), 43–54.

Hidayat, I. P., & Siswoyo. (2020). Analisa Risiko Kesehatan Dan Keselamatan Kerja Pada Proyek Pembangunan Perumahan Di Sidoarjo Jatim. *Jurnal Rekayasa Dan Manajemen Konstruksi*, *8*(1), 35–44.

Iswajuni, I., Soetedjo, S., & Manasikana, A. (2018). *Pengaruh Enterprise Risk Management (Erm) Terhadap Nilai Perusahaan Pada Perusahaan Manufaktur Yang Terdaftar Di Bursa Efek*. Journal of Applied Managerial Accounting, 2(2), 275–281.

Kementerian PUPR. (2021). Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia Nomor 10 Tahun 2021 Pedoman Sistem Manajemen Keselamatan Konstruksi. 1–38.

Kurniawan, A., & Wibowo, A. (2019). *Maturitas Enterprise Risk Management Kontraktor Besar di Indonesia dan Faktor-Faktor yang Mempengaruhinya*. 24(3).

Magdalena, S., Mansur, H. M., Kurniasari, D. E., & Miharja, J. (2022). *Risk Assessment Kesehatan dan Keselamatan Kerja (K3) pada Pekerjaan Bongkar Menggunakan Metode Hazard Identification, Risk Assessment, & Risk Control pada Pelabuhan Ciwandan di Banten*. Quantum Teknika : Jurnal Teknik Mesin Terapan, 4(1), 35–44.

Ni Kadek Sri Ebtha Yuni, I Nyoman Suardika, & I Wayan Sudiasa. (2021). *Risiko K3 Pada Pelaksanaan Konstruksi Bangunan Gedung Swasta.* PADURAKSA: Jurnal Teknik Sipil Universitas Warmadewa, 10(2), 317–324.

Pratama, M. F., Ismiyah, E., & Rizqi, A. W. (2022). Analisis Risiko (K3) Metode Hazard Identification Risk Assesment And Risk Control (HIRARC) di Departemen Laboratorium PT. ABC. Jurnal Ilmiah Giga, 25(2), 88.

Rikaz, S., Ulhaq, A. D., & Mulyono, R. H. (2020). *Design of Coso Enterprise Risk Management At Publishing and Printing Companies*. *E-Prosiding Akuntansi*, *3*, 1.

Tiurma Elita Saragi, R. E. S. (2019). *Keselamatan Dan Kesehatan Kerja (K3) Pada Proyek Pembangunan Rumah Susun Lanjutan Provinsi Sumatera Utara I Medan*. Jurnal Ilmiah Smart, III (2), 68–80.

Triase, R. M. (2019). *Analisis Manejemen Risiko Pembangunan Proyek Jalan Lintas Bawah Tanah Bunderan Mayjen Sungkono Surabaya*. *Jurnal Spesialis Teknik Sipil*, *1*(1), 1–19.

Trisiana, A., Yafi, D. S. A., & Ratnaningsih, A. (2019). *Assessment Risiko Kesehatan dan Keselamatan Kerja (K3) Menurut Variabel OHSAS Dengan Menggunakan Metode HIRA, HAZID dan HAZOP (Studi Kasus: Proyek Pembangunan Ciputra World Phase 3, Surabaya)*. *Jurnal Rekayasa Sipil Dan Lingkungan*, *3*(1), 28–37.

Wisudawati, N., & Patradhiani, R. (2020). *Analisis Risiko Keselamatan dan Kesehatan Kerja (K3) dengan Metode Hazard Analysis (Studi Kasus pada Proyek Pembangunan Perumahan)*. Integrasi: Jurnal Ilmiah Teknik Industri, 5(1), 29.