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Safety Management System Risk Analysis Construction In Embankment Reconstruction Palu City Road

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Abstract
In the road embankment reconstruction work in Palu City, work accidents often occur at the work site caused by a lack of understanding and application of construction safety management system problems in the field. The purpose of this study is to determine the safety risk factors that influence the implementation of the Construction Safety Management System in road embankment reconstruction work in Palu City, to determine the effect of work safety risks on the implementation time of road embankment reconstruction work in Palu City, and to determine the work safety risk management strategies applied in the implementation of road embankment reconstruction projects in Palu City to minimize the potential for work accidents and increase the effectiveness of the implementation of the Construction Safety Management System in road embankment reconstruction work in Palu City. The research respondents were 31 project owners, contractors, and consultants. Data collection techniques were through questionnaire surveys, interviews, and documentation. Data analysis used a risk matrix and multiple linear regression. From the results of the analysis that affect the implementation of the Palu City Inner Road Rehabilitation project, Reconstruction and Handling of the Rajamoili – Cutmutia Road Embankment, namely the risk of the merja method (X3) and the risk of financing and project management (X5) are included in the High Risk category and the risk of labor (X1), work equipment (X2), and materials and environmental conditions (X4) are in the Medium Risk category. All risk factors (X1–X5) have a positive and significant influence on the project implementation time. Each risk in the project has a different level of influence on the implementation time so that it requires an appropriate handling strategy.
Keywords: *Construction Project, Road Embankment, Construction Safety Management System, Implementation Time*

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I. INTRODUCTION

During the road embankment reconstruction project in Palu City, work-site accidents are still common. This is due to a lack of understanding and implementation of construction safety management systems in the field. Therefore, all parties involved in the project need to be aware of the risks. Improving knowledge and implementation of construction safety management systems to minimize the risk of workplace accidents. Implementing this system is crucial because workplace accidents not only harm the workers involved but also directly and indirectly impact the project [1]. Therefore, a risk analysis is needed to identify various risks related to the construction safety management system that may arise. The results of this risk analysis then need to be communicated to workers to raise their awareness of the implementation of the construction safety management system at the project site. Therefore, this study was conducted to further determine the safety risk factors that influence the implementation of the construction safety management system in the reconstruction of road embankments in Palu City.

The purpose of this study is to determine the safety risk factors that influence the implementation of the construction safety management system, the influence of work safety risks on implementation time, and the handling strategies implemented to minimize the potential for work accidents in road embankment reconstruction work in Palu City.

II. LITERATURE REVIEW

Several concepts and literature reviews that are related to and support the research object are as follows:

2.1 Road Embankment Preservation

Road embankment preservation is the process of maintaining and repairing embankment structures that serve to protect roads from potential damage due to erosion, flooding, landslides, or changes in soil stability [2]. Road embankments play a vital role in maintaining road function, especially in areas close to water bodies such as rivers, reservoirs, or beaches. Preservation measures are implemented to ensure that the embankment remains stable, safe, and able to withstand lateral pressure from the surrounding water and soil. This preservation not only emphasizes repairing the physical structure of the embankment, but also on the implementation of a construction safety management system to ensure that activities are carried out safely and comply with technical norms [3].

2.2 Construction Project Management

There are two types of building project management: project management and construction management. Project management can be described as a series of activities encompassing the planning, organization, leadership, and evaluation of a project by a team, optimizing the efficient use of resources to achieve predetermined objectives [4]. The primary tasks of project management include establishing the scope of work and the time schedule. Construction management is recognized as a distinct management discipline, aiming to organize and control the complex activities of project implementation. Therefore, management approaches or techniques that meet construction resource requirements are continually evaluated and adjusted to ensure ongoing work is completed [5]. Time control can be achieved through a precise and accurate time schedule tailored to the contractor's capacity and the contract duration set by the owner. This time schedule is complemented by the weight or value of the work presented in the form of a cumulative graph of each activity versus time [6].

2.3 Risk Management

Risk management encompasses all phases of risk-related work, including assessment, planning, control, and monitoring of accidents [7]. Risk management is the process of recognizing, analyzing, and controlling uncertainty, which serves to increase the outcome of favorable events and reduce the consequences of unfavorable events. Phases of risk management [8].

2.4 Occupational Safety and Health Management System (SMK3)

An Occupational Safety and Health Management System (OSHMS) is a framework, responsibilities, practices, and procedures for resources within a company designed to implement occupational safety management. OSHMS is defined as part of the overall management system that encompasses organizational structure, planning, responsibilities, implementation, application, achievement, assessment, and maintenance of occupational safety and health policies, with the aim of creating a safe, efficient, and productive work environment.

2.5 Safety and Health Risk Management in Projects

Risk management related to safety and health in construction projects is a crucial element that requires serious attention from all parties involved. The risk management process includes identifying, evaluating, and monitoring factors that could potentially endanger worker health and safety and impact the overall project's sustainability [9]. This discussion will explore various general approaches that can be applied to address health and safety risks in construction projects. The first step in risk management is risk identification. Project teams are required to recognize various types of health and safety-related risks, such as workplace accidents, exposure to hazardous materials, and unsafe working conditions. With a thorough understanding of the work environment and the types of tasks performed, risk identification can be more accurate.

2.6 Road Embankment

An embankment is a structure that functions to retain soil or water, built along roads, especially in locations that are at high risk of flooding, landslides, or have differences in elevation between the road and the surrounding area. The embankment construction process generally uses various types of materials adapted to the purpose and location of the construction. The choice of materials for embankment construction is greatly influenced by site conditions, technical requirements, costs, and the intended use of the embankment [10]. In any construction project, careful analysis is essential to determine the appropriate materials to ensure the strength, stability, and safety of the embankment being constructed.

III.Research methods

3.1 Project Overview

Palu City Inner Road Rehabilitation Project, Reconstruction and Handling of Rajamoili – Cutmutia Road Embankment, PT. Bumi Duta Persada as implementing contractor and PT. Oriental Consultant Global as supervising consultant. The Reconstruction and Handling of Road Embankment is located on Rajamoili – Cutmutia Road, Palu City, Central Sulawesi Province. The budget for the Rajamoili – Cutmutia Road

Embankment Reconstruction and Handling project is Rp. 249,498,846,620.00 with an implementation time of 540 calendar days.

3.2 Data Collection Techniques

The data collection technique in this study uses 2 data management methods, namely:

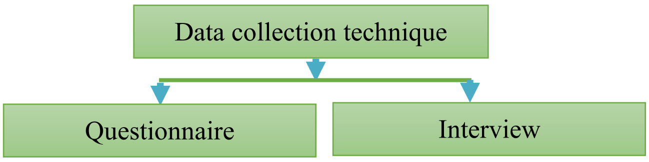

Figure 1. Data Collection Process

3.3 Research Instruments

There are two main factors that influence the quality of research results: the quality of the research instrument and the quality of data collection [11]. The instrument used in this study was a questionnaire. In quantitative research, the quality of the research instrument relates to the validity and reliability of the instrument, while the quality of data collection relates to the accuracy of the methods used to collect data [12]. Instruments in quantitative research include tests, interview guides, observation guides, and questionnaires. A questionnaire is a data collection technique that involves providing respondents with a set of written questions or statements to answer [13]. The instrument used in this study is intended to produce accurate data, namely by using a *Likert scale* used to measure the attitudes, opinions, and perceptions of an individual or group of people about a social phenomenon. The following is an explanation of the 5-point Likert scale:

Table 1. Questionnaire Answer Criteria

No	Criteria Evaluation	Likert Scale
1	Very Ineffective	1
2	No effect	2
3	Enough Influential	3
4	Influential	4
5	Very influential	5

Table 2. Parameters of "Probability/likelihood of hazard" in Standard AS/NZS 4360

No	Criteria Evaluation	Level
1	*Improbable* / Very Rare	1
2	*Unlikely* / Rarely	2
3	*Occasional* / Sometimes	3
4	*Likely* / Often	4
5	*Frequent* / Very Often	5

Table 3. Parameters of "Severity of hazard" in Standard AS/NZS 4360

No	Criteria Evaluation	Level
1	*Negligible* / Very Small	1
2	*Minor* / Small	2
3	*Moderate*	3
4	*Major* / Big	4
5	*Catastrophic* / Very Large	5

3.4 Data analysis

1. Risk Map / Risk Matrix

The risk research procedure is divided into two phases: risk analysis and risk assessment [14]. Both phases play a crucial role in establishing appropriate methods and procedures for risk management. After identifying potential hazards in the work environment, the next step is risk assessment. This process is carried out to assess the level of risk from potential hazards [15]. Likelihood and severity are the measures used to evaluate risk. The probability measure applied in this study is the frequency of events that could trigger a work accident, and likelihood is defined as the chance of an accident occurring in the workplace. Through a risk matrix table, the risk assessment illustrates the extent of the impact of identified potential hazards, an example of a hazard assessment [16].

Table 4. Australian Standard Risk Assessment Matrix – New Zealand

	Negligible (1)	*Minor* (2)	*Moderate* (3)	*Major* (4)	*Catastrophic* (5)
Improbable (1)	*Low*	*Low*	*Low*	*Low*	*Medium*
Unlikely (2)	*Low*	*Low*	*Medium*	*Medium*	*High*
Occasional (3)	*Low*	*Medium*	*Medium*	*High*	*High*
Likely (4)	*Low*	*Medium*	*High*	*High*	*Very High*
Frequent (5)	*Medium*	*High*	*High*	*Very High*	*Very High*

Table 5. Risk Level Scale

No.	Ranking Risk	Information
1.	17 - 25	*Very High Risk*
2.	10 - 16	*High Risk*
3.	5 - 9	*Medium Risk*
4.	1 - 4	*Low Risk*

2. Multiple Linear Regression

Multiple linear regression analysis was used to understand the impact of occupational safety risks on implementation duration [17]. In this study, the multiple linear regression analysis method was applied to examine the extent to which occupational safety risks affect implementation time. The multiple linear regression equation is:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$$

IV.Results and Discussion

In this study, the researchers selected subjects that reflect the characteristics/traits of the subjects. Below, we describe the general characteristics of respondents according to gender, age, education level, work experience, and expertise certification.

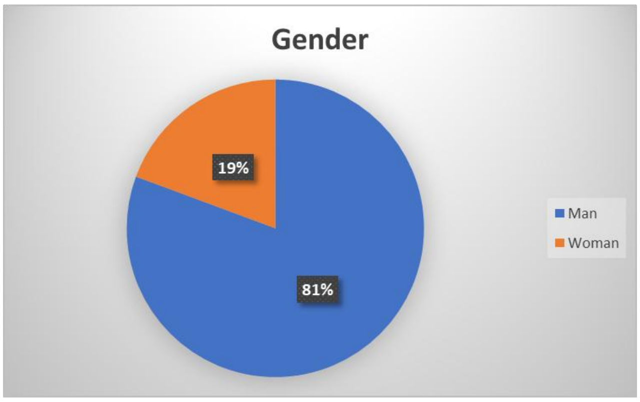

Figure 2. Respondent Gender Diagram

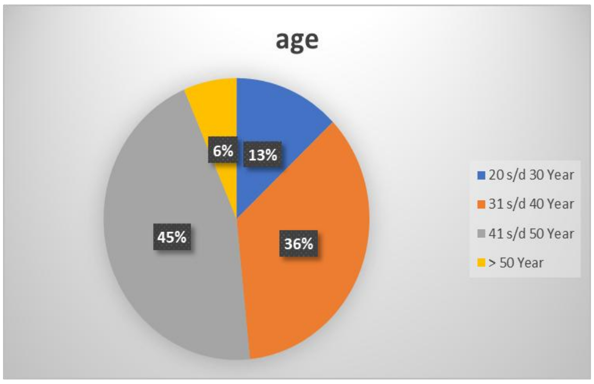

Figure 3. Respondent Age Diagram

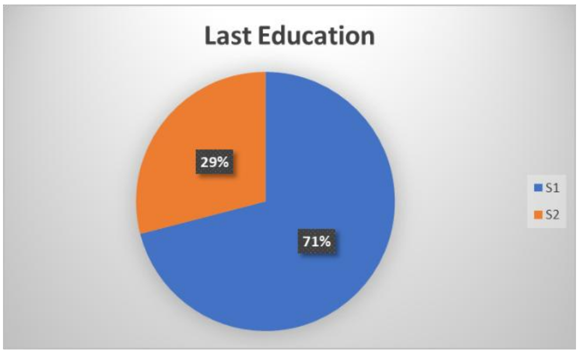

Figure 4. Diagram of Respondents' Last Education

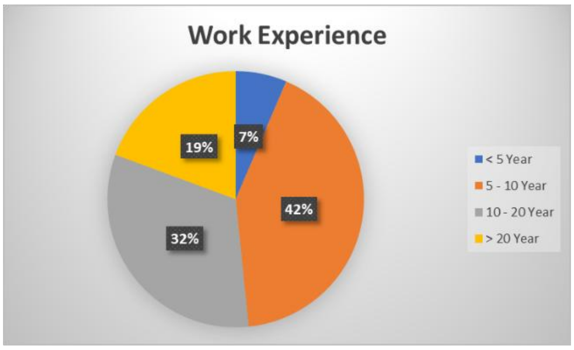

Figure 5. Work Experience Percentage Diagram

Figure 6. Respondents' SKK Diagram

4.1 Validation Test

To test the validity of a questionnaire from each of these variables, a validity test needs to be conducted. The correlation technique used to test the validity of the statement items in this study is the *Bivariate Pearson Correlation correlation (REMAKS)* [18]. This is done by correlating each indicator item score with the total variable score on the questionnaire. If rhitung > rTable, then the instrument is declared valid, and if rhitung < rtable then the instrument is declared invalid. It can also be done by using a *significance value* (2-tailed) < α =

0.05. In this validity test, the researcher tested the results of the answers of 50 respondents, using a confidence level of 95% or *a level of significance* (α) = 0.05, then the rtable was obtained at 0.355. The validity test that has been carried out in this study is shown in the following table:

Table 6. Results of the Validity Test of Research Variables

Correlations			
	r count	r table	Information
X1	.719**	0.355	Valid
X2	.699**	0.355	Valid
X3	.808**	0.355	Valid
X4	.648**	0.355	Valid
X5	.803**	0.355	Valid

From the results of the validity test calculations in the table above, it can be seen that rhitung > r tabel (0.355) all indicators in the questionnaire are declared valid, so that the data on each indicator can be analyzed further.

4.2 Reliability Test

A measurement with high reliability is one that produces reliable data. One frequently used method is reliability testing with *Cronbach's Alpha (CRONBACH)* [19]. If *the Cronbach's Alpha value* is >0.60, each tested variable has reliable indicators. The results of the reliability testing on the research variables can be seen in the table below:

Table 7. Reliability Test Results

Criteria Risk	***N of Items***	***Cronbach's Alpha Coefficient***	**Information**
Frequency	25	0.960	Reliable
Impact	25	0.956	Reliable

The results of the reliability test using SPSS software, the Cronbach's Alpha value obtained for the risk criteria for the frequency scale obtained a Cronbach's alpha coefficient value of 0.960. While for the risk impact coefficient value is 0.956. The minimum value for the Cronbach's Alpha coefficient is 0.600, so the value obtained based on the table above is acceptable or reliable.

4.3 Risk Mapping / Risk Matrix

Risk mapping or risk matrix is carried out to determine the risk assessment that influences the implementation of the construction safety management system on the Palu City Inner Road Rehabilitation project, Reconstruction and Handling of the Rajamoili – Cutmutia Road Embankment. In determining the frequency scale and impact scale on the quality of the implementation of the Palu City Inner Road Rehabilitation project, Reconstruction and Handling of the Rajamoili – Cutmutia Road Embankment, by taking the average value of the answers from each respondent based on a predetermined Liker scale, namely from 1 to 5. The following are the results of calculating the average respondent's answers for the frequency scale and risk impact scale.

Table 8. Category Risk

No.	**Identification Risk**	**Category Risk**	
X1	Labor	a)	1 *Very High Risk*
		b)	2 *Medium risk*
		c)	2 *Low risk*
X2	Equipment Work	a)	5 *Medium risk*
X3	Working Method	a)	2 *Very High Risk*
		b)	1 *High Risk*
		c)	1 *Medium risk*
		d)	1 *Low risk*
X4	Materials and Environmental Conditions	a)	5 *Low risk*
X5	Project Financing and Management	a)	1 *Very High risk*
		b)	4 *Medium risk*

The results of the risk assessment can be seen in the table above, obtained 5 risks that affect the implementation of the Palu City Inner Road Rehabilitation project, Reconstruction and Handling of the Rajamoili – Cutmutia Road Embankment. The very high risk category or the highest risk has 3 risk factors obtained, namely labor factors, work method factors and financing and project management. While the high risk category or high risk has 1 factor obtained also consisting of work method factors, then the medium risk category or moderate risk has 4 factors obtained also consisting of labor factors, work equipment factors, work method factors, and financing and project management factors. Then for the low risk category or small risk there are 3 factors, namely labor factors, work method factors, and material factors and environmental conditions.

4.4 Multiple Linear Regression Analysis

Multiple linear regression analysis was used to identify the impact of motivation and training on poverty levels (THE ROLE) [20]. In this study, multiple linear regression analysis was applied to demonstrate the extent to which occupational safety risks affect the duration of road embankment reconstruction work in Palu City.

1. F test

The F-test is a significance test of an equation used to determine the extent to which causal factors collectively influence contactor performance (DESIGN) [21]. The criterion is a sig. <0.05 or a calculated F-value > F-table. The results of the simultaneous test (F-test) for each variable question item in this study can be seen in the following table:

Table 9. Simultaneous Test (F Test)

ANOVA [a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6,065	5	2,013	20,596	.000 [b]
	Residual	2,322	25	1,973		
	Total	8,387	30			

a. Dependent Variable: time implementation

b. Predictors: (Constant), X2, X1, X3, X4, X5

From the results of the F test, a sig. value of 0.000 < 0.05 was obtained and the calculated F value was 20.596 > 2.460, which means that work safety risk factors jointly influence the implementation time.

2. T-test

The T-test or Partial Test is conducted to determine the influence of each independent variable (labor factor, work equipment factor, work method factor, material factor and environmental conditions and project financing and management) individually on the dependent variable (implementation time). This test can be done by comparing the calculated T and the T table so that the sig value is <0.05 or the calculated T value is > T table. The results of the partial test (T test) for each variable question item in this study can be seen in the following table:

Table 10. Partial Test (T-Test)

Coefficients [a]

Model		*Unstandardized Coefficients*		*Standardized Coefficients*		
		B	*Std. Error*	*Beta*	*t*	*Sig.*
1	(Constant)	.498	2,794		.265	.875
	X1	.785	.248	.682	6,606	.000
	X2	.730	.137	.660	5,535	.001
	X3	.893	.340	.780	7,868	.000
	X4	.682	.124	.524	5,320	.001

X5	.874	.296	.746	7,776	.000

a. Dependent Variable: time implementation

From the results of the T Test, the sig. value is 0.000 < 0.05 and the value of the labor factor is T count 6.606 > 1.696, the value of the work equipment factor is T count 5.535 > 1.696, the value of the work method factor is T count 7.868 > 1.696, the value of the material and environmental conditions factor is T count 5.320 > 1.696, and the financing and project management factor is T count 7.776 > 1.696, meaning that individually the independent variables of the labor factor, work equipment factor, work method factor, material and environmental conditions factor, and financing and project management factor have an effect on the dependent variable of implementation time.

3. Coefficient of Determination (R^2)

The coefficient of determination (R^2) indicates the extent to which the independent variable contributes to the dependent variable. The R-Square (R^2) value can be seen in the Model Summary table, the value of the coefficient of determination (R^2) is between 0 and 1. If the value is close to 1, it means that the independent variable provides almost all the information needed to predict the dependent variable. If the R^2 value is smaller, it means that the independent variable's ability to explain the dependent variable is quite limited.

Table 11. Summary Model Test Results

Model Summary

Model	*R*	*R Square*	*Adjusted R Square*	*Standard Error of the Estimate*
1	.930 [a]	.870	.823	31,404

a. Predictors: (Constant), X2, X1, X3, X4, X5

From the Model Summary test results table, the R-Square (R^2) value was obtained, namely 0.930 or 93%, which shows that the work safety risk factor in influencing the implementation time was 93% or strong, while the remaining 7% was explained by other variables besides the independent variables outside the research.

4. Multiple Linear Equations

Analysis multiple linear regression used For prove to what extent does it influence factor risk safety Work to time implementation with equality that is:

$Y = a + b\ 1\ x\ 1 + b\ 2\ x\ 2 + b\ 3\ x\ 3 + b\ 4\ x\ 4 + e$

Analysis results multiple linear regression obtained

$Y = 0.498 + 0.785\ (X1) + 0.730\ (X2) + 0.893\ (X3) + 0.682\ (X4) + 0.874\ (X5) + 0.05$

The result of the equation regression and interpretation from analysis regression multiple is mark constant (a) is signed positive which is 0.498 which means show unidirectional influence between factor risk safety work and time implementation. Which means factor risk safety Work influential to increasing or decline time implementation. Research results show mark coefficient regression power work (0.785), value coefficient regression equipment work (0.730), value coefficient regression method work (0.893), value coefficient material regression and conditions environment (0.682) and value coefficient regression financing and management project (0.874). Since 0.893 > 0.874, 0.785, 0.730 and 0.682 then concluded method Work is more variables big its influence to time implementation.

4.5 Handling Strategy Risk Safety Work Applied in the Implementation of Reconstruction Projects Road Embankments in Palu City to Minimize Potential Accident Work and Increase Effectiveness Application of SMKK in Work Reconstruction Road Embankment in Palu City.

1. Identification and Analysis Risk

This strategy done with recognize all over potential dangers that can happen during implementation projects, such as risk landslide embankment, crushed by material, or accident consequence use tool heavy. After danger identified, carried out analysis level risk based on possibility occurrence and impact to safety worker.

2. Coordination Between Teams and Stakeholders

Good coordination between contractor, consultant supervisor, government regions and communities around is key success implementation of SMKK. Routine communication is carried out through meeting coordination For discuss progress projects, K3 evaluations, and solution on obstacles in the field. With existence synergy between parties involved, each potential risk can handled with fast and effective, and implementation culture safety Work can running optimally throughout stages project reconstruction embankment road.

3. Use of Personal Protective Equipment (PPE)

The use of PPE is step base but very important in guard safety workers on the project. Every worker required use appropriate PPE with type work done, such as helmets, vests reflective, sheath hands, shoes safety, masks, and shields ear. Supervision to eligibility and discipline use of PPE is carried out regularly to ensure protection maximum to risk accident or exposure hazards in the work area.

4. Management Environment Work

Environment safe and orderly work neatness is very influential to safety and productivity power work. Management done with guard cleanliness of the work area, organize system drainage so that it does not happen puddles, providing adequate lighting, as well control dust and noise. In addition, the work area must own track evacuation and signs warning clear danger. With environment managed work good, potential accident consequence condition No safe can reduced in a way significant.

5. Supervision and Enforcement Discipline

K3 supervision is carried out by officers safety and foreman field For ensure that all procedure safety executed with true. Routine inspections, patrols safety, as well as meeting evaluation done For monitor compliance worker to K3 regulations. Implementation sanctions for violations and giving award for disciplined workers become part from enforcement strategy discipline. With consistent supervision, culture safety can formed and risk accident Work can minimized.

6. K3 (Occupational Safety and Health) Planning

K3 planning aims For ensure every stages work own procedure clear and measurable safety. In the project reconstruction embankment road, the K3 plan includes compilation policy safety, standards operational work procedures (SOP) safe, provision facility responsive emergency, and timetabe routine check-ups of tools and work area. With careful planning, control risk can done in a way systematic and appropriate with provision in System Management Occupational Safety and Health.

7. Training and Socialization

Occupational health and safety training and outreach are provided to all workers to ensure they understand potential hazards and how to work safely in the field. This includes training on the use of heavy equipment, evacuation procedures, and the proper use of personal protective equipment. Outreach is conducted periodically through occupational health and safety meetings and daily briefings in the field. By increasing worker knowledge and awareness of the importance of safety, compliance with occupational health and safety regulations can improve, thereby reducing the risk of workplace accidents.

4.6 Discussion Between Risk Matrix and Multiple Linear Regression Analysis

Based on the results of the risk matrix analysis and multiple linear regression analysis, the following results were obtained:

Table 12. Results of Risk Matrix Analysis and Multiple Linear Regression Analysis

No.	Risk Identification	Risk Categories Using *Risk Matrix Analysis*	The Effect of Risk on Implementation Time Using *Multiple Linear Regression Analysis*

X1	Labor	8.50 (*Medium Risk*)	.785
X2	Equipment Work	7.01 (*Medium Risk*)	.730
X3	Working Method	12.13 (*High) Risk*)	.893
X4	Materials and Environmental Conditions	6.29 (*Medium Risk*)	.682
X5	Project Financing and Management	10.12 (*High) Risk*)	.874

The risk of working methods in road embankment reconstruction is categorized as High Risk because field conditions often show a mismatch between planning and implementation. In the field, work is often carried out on existing soil that is unstable, saturated with water, or experiencing a decrease in bearing capacity, while work methods are not always adapted to these conditions. Furthermore, the financial risk in road embankment reconstruction is categorized as High Risk because field conditions often differ from initial planning assumptions. In practice, more extensive embankment damage, very soft subgrade, or water influences (seepage, flooding, tides) are often found that are not identified in detail during the survey stage. These conditions require design changes, increased work volume, the use of special materials, and more complex construction methods. As a result, project costs increase significantly, disrupt contractor cash flow, and the potential for late payments or additional cost claims is high.

V. CONCLUSION

The risks affecting the implementation of the Palu City Inner Road Rehabilitation project, Rajamoili – Cutmutia Road Embankment Reconstruction and Handling, namely the risk of the merja method (X3) and the risk of financing and project management (X5) are included in the High Risk category, this indicates that these two aspects have the greatest potential to cause serious impacts on the smooth running of the project. Priority control and mitigation are needed, such as improving work method planning, procedural supervision, and strengthening financial management. Then all risk factors (X1–X5) have a positive and significant influence on the project implementation time. This means that the higher the risk level, the greater the potential for delays in work time. The strategy used tends to be Risk Reduction as the main step, in the work method and Risk Transfer in the financing aspect to reduce the risk burden directly. In addition, additional strategies such as Risk Retention for labor risks, Risk Transfer for equipment, and Risk Avoidance for environmental risks can help minimize potential operational obstacles.

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