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Assessment of Building Damage using Hazard Identification and Risk Assessment Methods for School Buildings in Jember District

Sih Liberti[a]*, Anik Ratnaningsih[b], Ketut Aswatama[c]

[a,b,c]Departemen of Civil Engineering of Jember University, Jl.Kalimantan 37, Jember 68121, Indonesia

[a]Email:161920301015@students.unej.ac.id

[b]Email: ratnaningsih_anik@unej.ac.id

[c]Email: ketut.teknik@unej.ac.id

Abstract

The damage of school buildings is a serious safety problem in Indonesia,in wich more than 60% of primary school buildings in Indonesia show severe damage which endangers the people inside. The purpose of this study is to analyze the risk of damage building components, using risk assessment methods (Hazard Identification and Risk Assessment). The results of HIRA analysis show that there were 6 units with light damaged, 15 units with severe damage and 17 units with damage. Therefore, it is known that the high risk was due to building collapse. Meanwhile the response to the medium risk is repairing the existing damage. If the damage become the high level of risk and cause casualties, it must be handled with the rehabilitation,. Routine maintenance is performed on a primary case with minor damage to the primary school. A maintenance case is performed by a minor case on a primary school that can be reduced or even eliminated. If countermeasures are done and on target, it is expected that the existing risk can be reduced or even eliminated.

Keywords: Damage Assessment; HIRA; Risk Analysis.

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* Corresponding author.

1. Introduction

The damage of primary school building should be handled as a result of damage to the primary school building can have an impact note only learning process but also may lead to collapse of the building which will lead to injuries and even fatalities. Studies show that the structural damage to buildings is the structure cause of the load [6].Building strength can be reduced due to the nature of the building, the effects of load or construction failure [9]. Based on case studies conducted specifically in Jember the main problem is the method of assessment used only by the volume of any damage resulting statistical data are less clear. It requires a method that can provide a solution to a complex problem with varied criteria. Detecting damage caused to the building is an important part of building structural maintenance activities or vulnerability assessment [11] Vulnerability assessment can be done in four stages: identification of events, the location of the damage, the severity of the damage and the age of the building [9]. The risk assessment is a systematic examination and actual to identify and provide conclusions regarding the potential occurrence and serious danger and possible consequences [3], Carter and Smith suggests that the identification of hazards is a fundamental criterion for assessing risk [2]. While risk management includes identifying the highest hazards, assessing risks and recommending risk response[8], Sachan and Zhou state that risk management approach is applied to take into consideration of the actual condition of the components and risk [5] In the AS / NZS4360: 1999 hazard or danger is defined as a source or a situation of danger that potentially harm humans, affecting the health, causing damage to buildings, environments, or a combination of all. Dangers are associated with a potential or possibility. While the level of risk is the possibility of something to cause damage or harm. The rate or size of the risk is determined by the frequency, duration and severity of occurrence [10] HIRA is a hazard identification method by defining and describing the dangers to characterize hazards based on probability, frequency, severity, evaluation of potential consequences including the loss and injury[4], Risk assessment should include information to make appropriate hazard identification of priority so that a proper mitigation to reduce the impact and losses that may occur. The results of hazard identification are analyzed using a risk matrix, that can be formulated mathematically, the formula can be used to calculate the risk value based on AS / NZS4360: 2004. Research conducted by Saedi and his colleagues on hydroelectricity through HIRA method classifies hazards into five categories: physical, chemical, biological, ergonomic and electricity hazards. The risk assessment is done by multiplying the probability and severity[6] as in the formula in Eq.1.

$$Risk = Consequence \times likelihood \qquad (1)$$

Whereas Al-Anbari clarified risk into two groups, health risk and safety risk[1], Where risks can be measured by multiplying events or the possibility of event. The existing values were considered as a Risk Assessment of Safety and Health (RASH) for building construction. The formula for assessing risk classifications can be seen in Eq.2

$$R\,(Ls+Lh) \times (Cs + Ch) \qquad (2)$$

Where Ls and Lh are the likelihood for health and safety, while Cs and Ch are the Consequences for health and safety. From the study of the existing literature, it can be concluded that classifying the risk can be achieved by

HIRA (Hazard Identification and Risk Assessement) which is a common method for measuring risk. The main objective of this study is:

- To classify the elementary school building damage and identify the level of danger through direct observation
- To measure and classify building damage risk zone for each primary school to determine the likelihood and severity
- To provide a response to the risk of damage to primary schools

2. Methodology

2.1. Population and sample size

The research was conducted in Jember district especially in 5 large districts area, (1) Sumberbaru, (2) Bangsalsari, (3) Silo, (4) Tempurrejo and (5) Tanggul. This study used descriptive research trough the collection of primary data, selecting and identifying the type of damage observed, determining the consequences and likelihood, then determininge and evaluatinge risk matrixAt the end, the analysis results were grouped into classes The primary data were obtained from the survey results using the application's called Takola. While the secondary data were obtained from the database of Jember district education offices. The number of samples was determined using random sampling method, i.e. data collection technique that alter the amount of data by utilizing a relative measurement of the sample through the sampling unit [7]. The population in this study were all public elementary school buildings with a minimum of 200 students in Jember district namely 61 units spread into 5 districts as shown in Fig.1

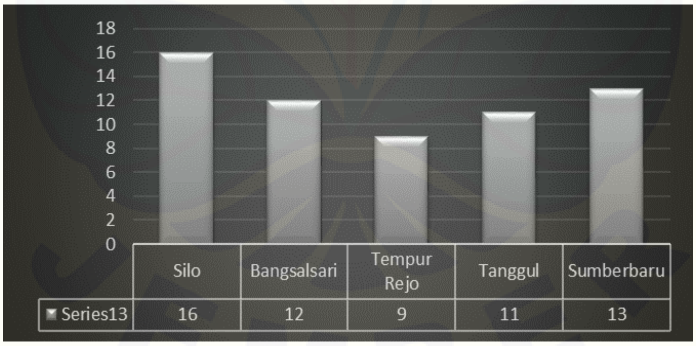

Figure 1: population size

To determine the size of the sample, the formula as seen in Eq.3 is used.

$$n = \frac{N}{1+N\alpha^2} \qquad (3)$$

Where n is the minimum sample size and N is the population size, α is significance level of 0.1. Thus, we get the sample size of 38 primary schools proportionslly divided into the following sub-district as shown in Fig.2

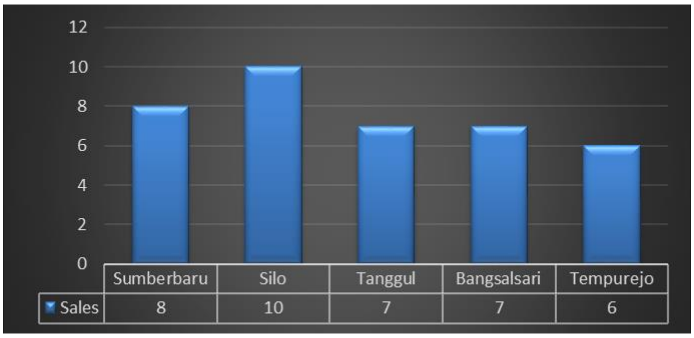

Figure 2: sample size

To assess the risk in every activity, quantitative technique such as Risk Assessment is adopted. The overall methodology is shown in Fig. 3

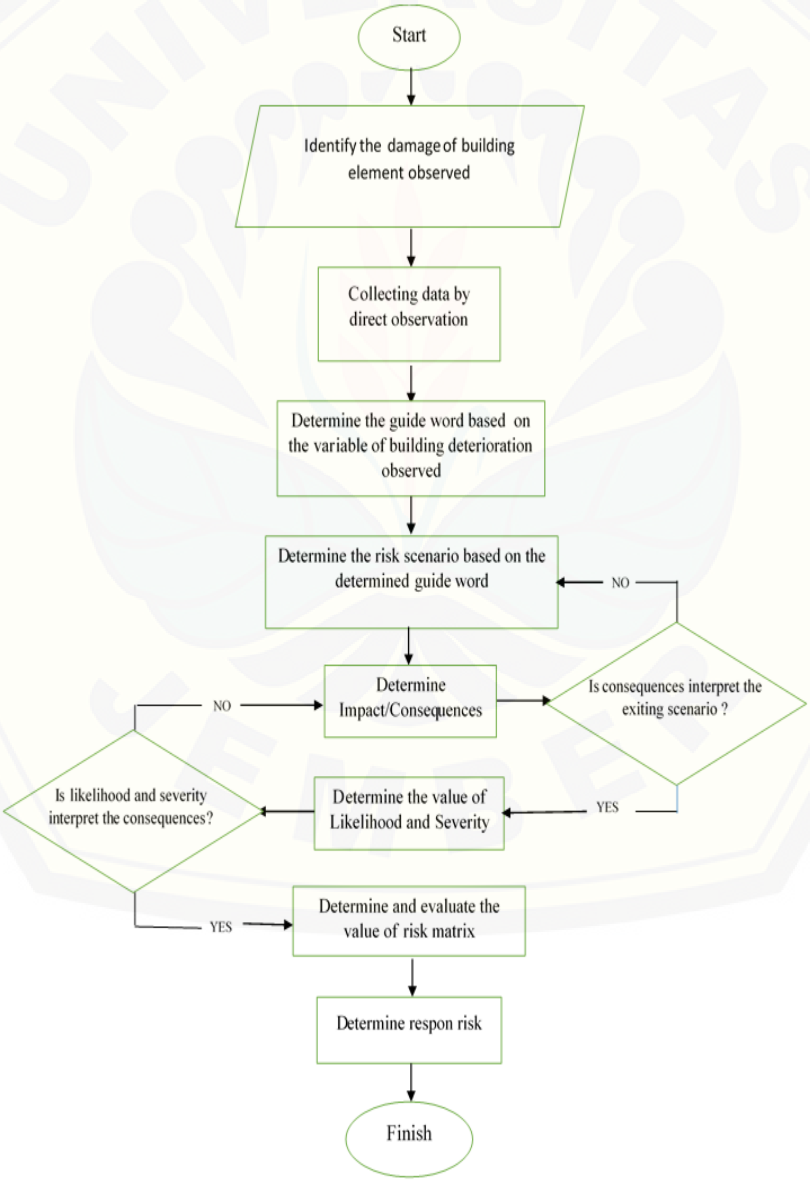

Figure 3: research methodology

2.2. Identification of the elements of building damage

Elements of building damage are classified as shown in Table 1.

Table 1: Elements damage observed

Component	Element	Sub-Element
Structural	Top	Roof truss
	Middle	Column
		Beam
		Ring balk
		Brick
Non-Structural	Roof coverings	Coverings
	Ceiling	Wall paint
	Wall	Plastering
	Doors and windows	Door and window frames
		Door and window glass
	Floor	Floor coverings
	Electrical installation	Lighting

2.3. Determine guide word and scenario

Guide word is the word for guidance in writing the scenario used in the study wich is based on elements of the damage observed. Scenario is an extension of your previous word which states the case in general. The determination is based on the element of damage scenarios that have been identified, the scenario in this study can be translated as the potential risks arising from the existing damage components.To identify the hazards that arise as a result of damage to the elementary school building, direct observation and review reports or documents were conducted. Hazards are classified as damage of elementary schools buildings that can be observed visually

2.4. Determine impact/consequences

To determine the events, it can be seen from the scenario that is superbly prepared. The scenario has been created and determined the causes or even if that led to a scenario that happens. One scenario may appear several events, therefore, event can be determined what the consequences or impact that can be caused. The determination of the impact as the severity reference is shown in Table 2

Table 2: Consequences

Rating	Description	Building strength and function	Description
1	insignificant	can be ignored	Conditions on these components are still functioning well, there is regular maintenance
2	Minor	Very little can be ignored	Conditions on these components still function no routine maintenance
3	Moderate	Small does not affect the strength of the building but needs improvement	Damage occurs in non structural components more often seen as damage to the finish does not affect the function of the building
4	Major	Medium if neglected can affect the strength of the building and the building functions	Damage occurs in some non-structural components, as well as structural, functional interrupt
5	catastrophic	Severe can cause collapse or collapsed buildings and stop the activities of occupants in buildings	Damage occurs in the majority of building components both structural and non-structural

2.5. Determine likelihood

Likelihood or probability is defined as the frequency of occurrence of a particular hazard. Thus, the possible values and descriptions are used to determine the level of frequency of occurrence of each damage as shown in Table 3.

Table 3: Consequences

Rating	Likelihood	Description
5	Almost Certain	Occurs more than once in a year
4	Likely	Occurs once in 1-5 years
3	Posibble	Occurs once in 5-10 years
2	Unlikely	Occurs once in 10-20 years
1	Rare	Occur less than once in 20 years

Source: AS / NZS 4360

2.6. Risk matrik

Risk matrix value is calculated by multiplying risk probability and severity as shown in Table 4

Table 4: Risk Matrix

SCALE		consequenses				
		5	4	3	2	1
likelihood	1	5	4	3	2	1
	2	10	8	6	4	2
	3	15	12	9	6	3
	4	20	16	12	8	4
	5	25	20	15	10	5

Source: IEC 61 882: 2001

Information :

: Very High Risk (16-25)

: High Risk (11-15)

: Moderate Risk (6-10)

: Low Risk (1-5)

Classification of the existing risk value is classified using the formulation of risk quadrant into damage classes of low, medium and high risk level as shown in Table 5

Table 5: Risk Level

Risk Level	Damage level	Percentage Damage
low Risk	low	$\leq$ 30%
medium Risk	moderate	30% - 45%
High Risk	High	$\geq$ 45%

2.7. Risk response

After categorizing the risk zone, it is advisable to follow the risk response as shown in Table 6.

Table 6

Damage level	Risk response
low	Routine care of primary school building
moderate	Minor repairs damaged building elements
High	Major rehabilitation

3. Result and discussion

After analysing the risk to the sample size, the total risk value for each primary school in percent is shown in Fig 5 for low risk level, Fig 6 for Medium eisk level and Fig 7 for High risk level

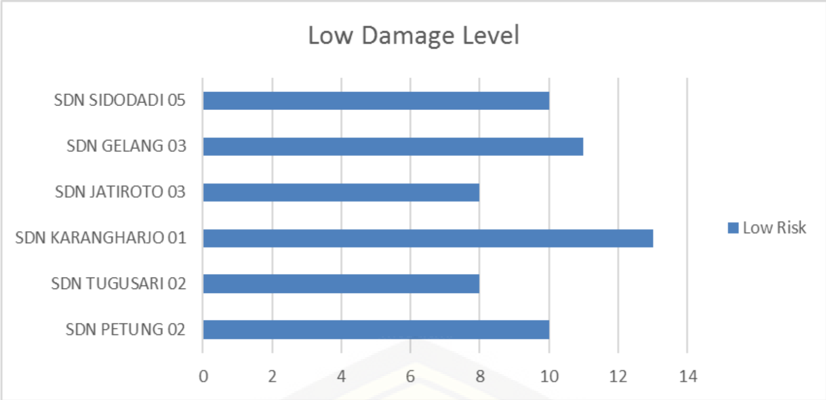

Figure 5: Low Risk Level

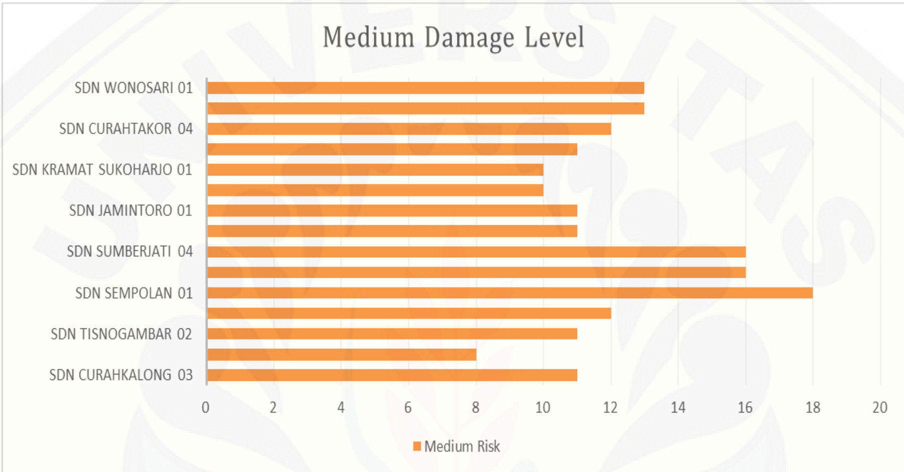

Figure 6: Medium Risk Level

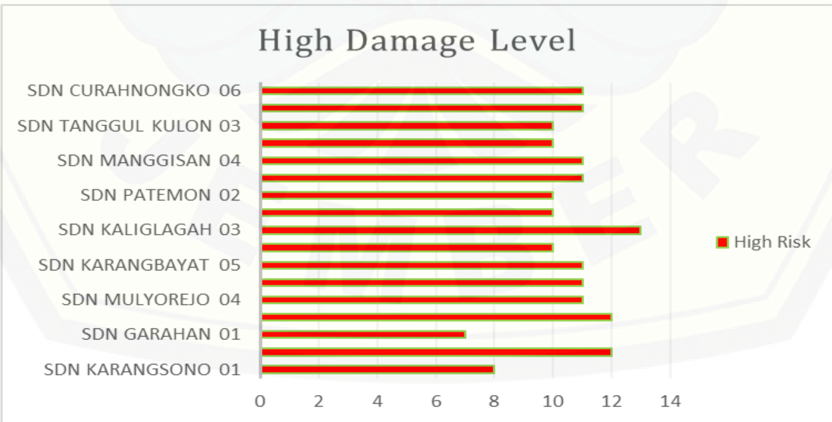

Figure 7: High Risk Level

The assessment results obtained from analysing the risks are 19 types of hazards in the form of a potentially building damage and malfunction of the collapse of the collapse of school buildings covering damage

3.1. Risk Assessment (RA)

As shown in Table 7 analysis of hazard in SDN Curahnongko 02, has a value of Very high risk, 7 sources of hazard that has the value High risk, 6 sources hazard that have the value Moderate risk, 5 sources of hazard have a value of Low risk. Likelihood of multiplication result between the Consequences will get the level of risk of damage to the building of SDN Curahnongko 02 that illustrates the size of the impact of the identified potential hazards.

Table 7: Risk Assessment of SDN Curahnongko 02

Number Damage	Risk Score			Risk Level
	C	L	Level of Risk	
1.1 Deflection	5	1	5	low risk
1.2 Corrosion	4	2	8	moderate risk
1.3 Connection loose	2	2	4	low risk
2.1 Cracks	1	3	3	low risk
3.1 Cracks	3	4	12	High risk
4.1 weathered and spotting	3	3	9	moderate risk
5.1 Cracked and broken	3	4	12	High risk
6.1 Spots on the panel	3	3	9	moderate risk
6.2 Panel off	2	4	8	moderate risk
7.1 The damaged paint layer after painting	3	4	12	High risk
8.1 The damaged paint layer after painting	3	4	12	High risk
9.1 Muai timber with 2150 mm high	4	3	12	High risk
9.2 weathered wood	3	3	9	moderate risk
10.1 Wood weathered	2	2	4	low risk
11.1 Gaps between the door	4	3	12	High risk
11.2 weathered wood	4	2	8	moderate risk
12.1 Broke and off	4	4	16	Very High Risk
12.2 Stepping	4	4	16	Very High Risk
13.1 The lighting installation is damaged	5	3	15	High risk

3.2. Risk Level

The next level of risk through matrix quadrants using IBM SPSS Statistic 22, showed a 3 source of hazard into the category of low risk, 5 medium-risk and 11 high-risk as shown in Fig.8

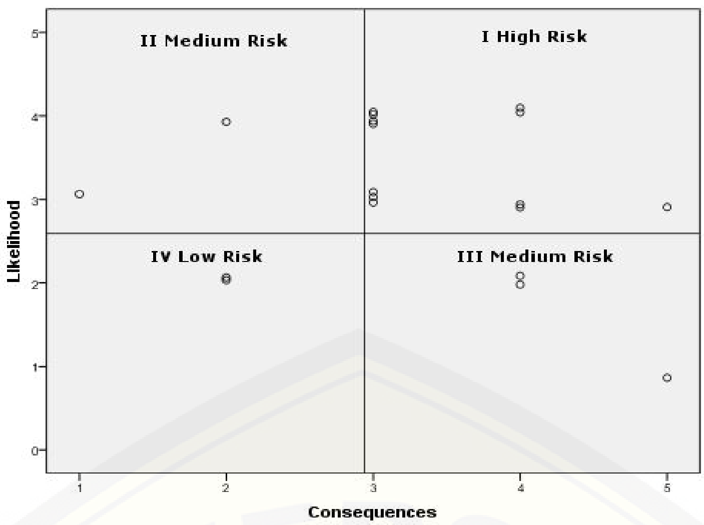

Figure 8: Risk Level

3.3. Determine the risk response

Having obtained the value of the risk level, risk response needs to be done. For high building damage, it needs reconstruction, minor damage needs refinement, while moderate and low risk needs routine care. Furthemore, the results are grouped into three levels of damage is low, moderate and high damages. According to the table of SDN Curahnongko 02, the results show high-risk damage of more than 60%. Risk analysis step was then performed again until all the samples were analysed If the results of the assessment are compared with the weighting method this volume shows a significant difference with damage analysis using the hazard identification method and risk assessment (HIRA) that occurs because many factors in the analysis are not considered.The results of this study need to be further analyzed, i.e. the need for inspection of damage to buildings by means of more accurately performed by specialized technical team in accordance with the field, so that th research results can be more clearly and convincingly

4. Conclusion and Recommendations

The conclusions and recommendations that can be drawn from this study are as follows:

- The analysis is based on methods of HIRA (Hazard Identification and Risk Assessment) known as level of risk of damage to the primary school building in five major districts in Jember wich can be classified into mild impairment level in 6 elementary schools, 15 primary schools show damaged and 17 were severely damaged primary schools
- Potential dangers that exist on any building damage are identified through direct observation. Then the risk is measured by probability (likelihood) and severity (consequences) based on the values shown by security experts
- Damage is classified through a risk matrix quadrants where there are three classes of damage is minor damage to the percentage of damage is less than 30%, medium damage between 30% -45% as well as

severe damage to more than 45%

- Response risk from each class can be suggested that heavy rehabilitation for severe damage, repair damaged components for medium damage and routine maintenance for minor damage

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