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ANALYSIS OF BUILDING DAMAGE AND RELIABILITY IN ENSURING SAFETY, HEALTH, COMFORT, AND CONVENIENCE FOR USERS

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ABSTRACT

A functional building is a building that can provide security, comfort, health, and convenience for its users. This can be measured by analyzing the level of damage to buildings and their reliability. A building may suffer damage from time to time due to aging, therefore regular inspection and maintenance is required to assess the intensity of the damage and its level of reliability. The purpose of this research is to determine the level of damage and reliability of the building in order to ensure safety, comfort, health, and convenience for users. The research was conducted through field observations of architectural, structural, utility, accessibility, as well as building and environmental aspects based on Ministerial Regulation No. 16/PRT/M/2010, Ministerial Regulation No. 29/PRT/M/2006, and Ministerial Regulation No. .26/PRT/M/2008, as well as relevant studies. The analysis was carried out using a quantitative weighting system, calculating the percentage of the damaged quantity to the total quantity. The results showed that the building suffered mild to moderate damage with reliability classified as less reliable and unreliable. Recommendations based on the level of damage and reliability of the building include rehabilitation (repairing damage without changing function), renovation of unreliable aspects (repairing damage that can change function), and re-function or redesign of unreliable aspects.

Keyword: *Building Evaluation, Functional building, Building Damage, Building Reliability,*

1. INTRODUCTION

A safe residential building must meet functional requirements in order to ensure safety, health, comfort, and convenience for users. Generally, buildings are planned according to their intended lifespan, so after reaching the planned lifespan, an evaluation needs to be conducted to assess the potential damages that may occur and ensure that the building remains safe for occupancy [1]–[3]

The evaluation of a building, as stated in Ministerial Regulation No. 16/PRT/M/2010 regarding periodic technical inspections of buildings, emphasizes the need for regular inspections and maintenance of a building to assess the intensity of damages caused by various factors, including natural disasters (earthquakes, floods, landslides, ground subsidence, and others), the end of service life, the aging of the building, human behavior, excessive functional loads, as well as physical and chemical processes.
The classification of damage is categorized into three types: mild damage, moderate damage, and severe damage [4]Furthermore, the results of the evaluation of the building's physical condition are analyzed in terms of the building's reliability in meeting the requirements for safety, health, comfort, and accessibility based on Ministerial Regulation No. 26/PRT/M/2008 [5].

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Safety requirements must be fulfilled by a building in order to support the structural load and the building's ability to prevent and mitigate the risks of fire, lightning, electrical installations, and security against explosive materials. Health requirements refer to the fulfillment of ventilation, lighting, sanitation, and the use of building materials that have no adverse effects on users and the surrounding environment. Comfort requirements for building structures include the comfort of spatial movement and inter-room relationships, indoor air conditions, views, as well as vibration levels and noise levels. Convenience requirements encompass the ease of access to, from, and within the building structure, as well as the completeness of infrastructure and facilities for building utilization. Ease of access to, from, and within the building structure includes the availability of facilities and easy, safe, and comfortable accessibility, including for people with disabilities and the elderly[5]

Regarding the determination of the building's reliability, it should be based on Ministerial Regulation No. 29/PRT/M/2006, which provides guidelines for technical requirements for building structures, with assessments of reliability in terms of architectural aspects, structure, utilities, accessibility, and building and environmental arrangements[6]

The results of the analysis of the physical condition evaluation and the reliability level of the building are expected to provide information to users regarding the level of building damage and reliability. They also serve as the basis for recommendations for further actions, which can be used as a consideration for decision-making regarding the maintenance and care of the building in accordance with Ministerial Regulation No. 24/PRT/M/2008[5]

Maintenance and care activities refer to efforts to repair and/or replace parts of the building structure, components, building materials, and/or infrastructure and facilities to ensure that the building remains functional (curative maintenance). There are several maintenance and care measures for buildings, including: Rehabilitation: Repairing partially damaged buildings with the intention of retaining their original architectural and structural aspects while allowing changes to the utilities to accommodate specific functions; Renovation: Repairing partially severely damaged buildings with the intention of using them for specific functions, which can remain the same or change, involving improvements to the architecture, structure, and utilities of the building; Restoration: Repairing partially severely damaged buildings with the intention of using them for specific functions, which can remain the same or change, while preserving the architectural aspects of the building. However, changes can be made to the structure and utilities [5]Furthermore, the report on the analysis and evaluation of the building can be used as a requirement for obtaining a Certificate of Building Fitness (SLF) in accordance with Ministerial Regulation No. 25/PRT/M/2007, which provides guideline for the issuance of SLF for building structures [7]

Several researchers have conducted studies to evaluate the fitness of buildings. Examined the level of building damage in middle schools (SMP) in Maluku [8]. Studied the reliability of the administrative building of Teuku Umar Meulaboh University [9]. Evaluated buildings in earthquake-prone areas [1]. An evaluation of the reliability of reinforced concrete structures against corrosion [10]. An evaluation of buildings to ensure user safety [11]. A case study on the structural assessment of fire damaged building[12]

Based on previous studies and regulations emphasizing the importance of evaluating buildings after reaching the planned lifespan, it is necessary to conduct evaluations on buildings with such conditions. The research focuses on buildings in the UIN Sunan Ampel Surabaya, most of which were constructed in 1972 and have exceeded the planned lifespan. Additionally, visually, the buildings appear to have experienced damage. Therefore, this study is essential in providing information and recommendations for stakeholders to take appropriate actions.

2. RESEARCH METHODOLOGY

The research was conducted on the lecture buildings within the campus environment of Sunan Ampel State Islamic University, located at JL Ahmad Yani No. 117, Surabaya. The research consisted of several

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stages, including the initial/preparation stage, research implementation stage, data analysis stage, and research completion stage, as illustrated in Figure 1.

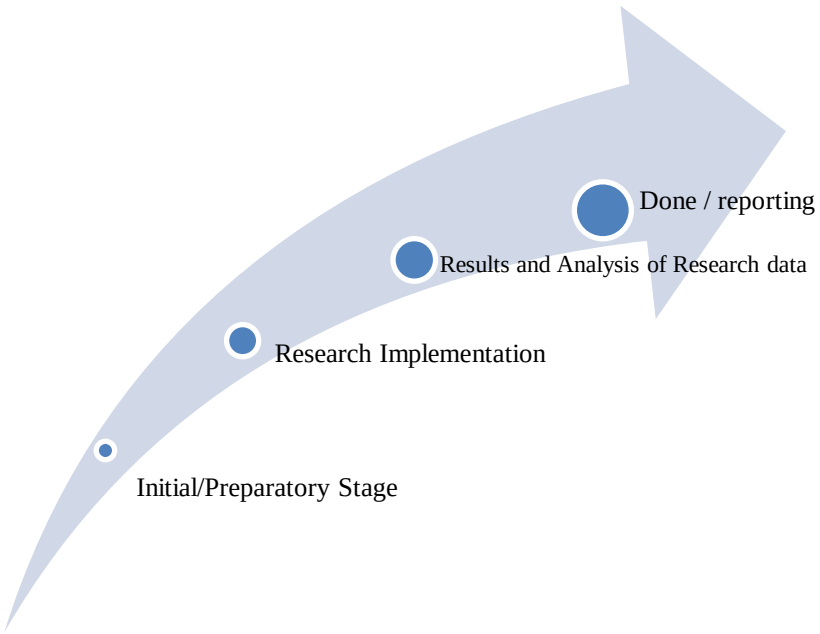

Figure 1. Research stages

Initial/preparatory stage: This stage includes reviewing relevant literature on the research topic, determining objectives, and developing research instruments.
Research implementation phase: Data collection on research objects was carried out through field observations. The research object consists of 8 lecture buildings in the UIN Sunan Ampel Surabaya campus.

Stages of data analysis: Examination of building damage based on Ministerial Regulation No. 16/PRT/M/2010, which provides technical guidelines for periodic inspection of building structures [4]. Based on this regulation, an overview of the level of damage to buildings is obtained. Types of damage to buildings are classified as mild, moderate, and severe. Furthermore, the reliability analysis of the building is carried out. The inspection results are analyzed using a quantitative weighting system, namely calculating the percentage of the amount of damage to the total amount. This is then compared with the reliability assessment criteria based on Ministerial Regulation No. 29/PRT/M/2006 and Ministerial Regulation No. 26/PRT/M/2008 [5], [6]Assessment criteria are presented in Table 1 to Table 3.

Table 1. Criteria for assessing building damage

Type of damage	Pattern of damage
Low damaged	Damage that occurs to non-structural components, such as roof coverings, ceilings, floor coverings, and infill walls
Moderate damaged	Damage to some non-structural components, and/or structural components such as roof structures, floors, etc.
Heavy damage	Damage that occurs to most building components, both structural and non-structural

Source: Ministerial Regulation No 16/PRT/M/2010

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Table 2. Criteria for assessing building reliability

Assessed aspects	Assessment criteria %			Assessment percentage %
	Reliable	Less reliable	Unreliable	
Architecture	95-100	75-<95	<75	10
Structure	95-100	85-<95	<85	30
Utilities &fire protection	99-100	95-<99	<95	50
Accessibility	95-100	75-<95	<75	10
building and land layout	95-100	75-<95	<75	10

Source: Ministerial Regulation No 25/PRT/M/2007

Table 3. Design of follow-up decisions

Reliability level	Recommendations
Reliable	It can be enable or enhanced
Less reliable	It can an be functioned and repaired. The form of improvement can be in the form of rehabilitation
Unreliable	Refunction and redesign must be carried out. The form of action can be renovation or restoration.

Source: Ministerial Regulation No. 24/2PRT/M/2008

The research completion stage is the final stage of the research, which involves the production of a written report presenting the research findings. This report aims to provide clear information about the research results. It serves as a reference for users/owners to carry out maintenance and care of the buildings in accordance with Ministerial Regulation No. 24/2PRT/M/2008. Additionally, the report serves as a document requirement for obtaining a Certificate of Building Fitness (SLF) in accordance with Ministerial Regulation No. 25/PRT/M/2007 [7]

3. ANALYSIS AND RESULT

3.1. Damage level of building

The assessment of the building damage level is conducted using an assessment form/checklist in accordance with Ministerial Regulation No. 16/PRT/M/2010. To determine the type and level of damage are carried out visual observations. Based on the observation and analysis of the forms of damage that occurred in the lecture buildings of UIN Sunan Ampel, it is found that the average damage is categorized as mild and moderate. The proportion of damage levels in the 8 lecture buildings is shown in Figure 2. In the case of mild damage, the damage occurs in some non-structural elements. Some of the visibly damaged components include doors/windows, external and internal wall coverings, floor coverings, and others. On the other hand, buildings that have experienced moderate damage show that the analysis of damage occurs in both non-structural and structural elements.

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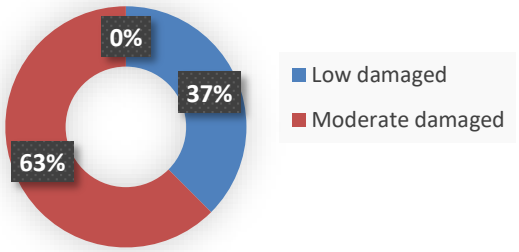

Picture 2. Percentage of Building damage

The pattern of damage includes damage to the outer and inner wall coverings, floor coverings, doors/windows, and even malfunctioning plumbing systems or rainwater drainage. The types of damage observed in the 8 buildings are shown in Figure 3 and Figure 4. Observations of building damage were also carried out by other researchers on different buildings with mild to severe damage[13]–[16] .

Picture 3. Moderate level of damage

Figure 4. Light damage level

3.2. Reliability Level of Building

The examination of reliability is conducted on five aspects: architectural aspect, structural aspect, utilities and fire protection aspect, accessibility aspect, and building and environmental arrangement aspect [6]Reliability in the architectural aspect is evaluated by assessing the functional condition of

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components against their maximum value. A building is evaluated in terms of its architectural aspect and categorized as reliable if it meets the specified reliability percentage as shown in Table 2. The evaluation of the architectural aspect aims to assess the reliability level of the building in terms of its comfort. The assessment includes the comfort of both indoor and outdoor spaces, with respective percentages of 80% and 20%. The percentage of reliability levels in the architectural aspect is shown in Figure 5.

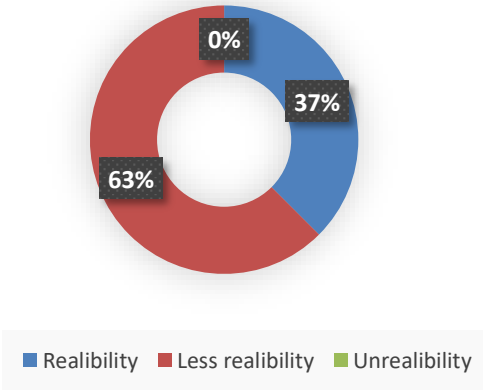

Figure 5. Reliability of Architectural aspects

The percentage of reliability levels in the architectural aspect shown in Figure 5 indicates that the majority of the building falls into the less reliable category. This is due to the high number of damaged components, such as peeling walls, damaged doors and windows, floor coverings, ceiling coverings, and so on. [2], [8], [17]
Reliability in the structural aspect is assessed to gather information about the building's condition in supporting structural loads. The percentage of reliability levels observed in the structural aspect is shown in Figure 6.

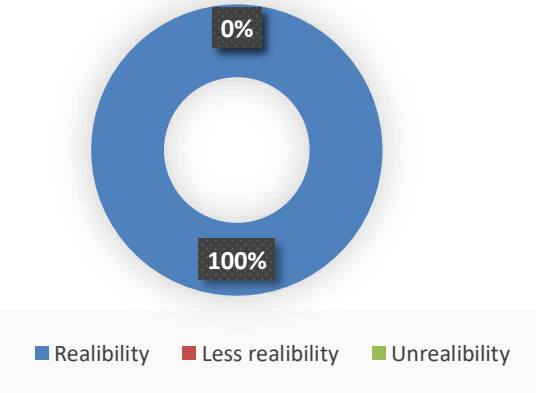

Figure 6. Reliability of structural aspects

The analysis of structural reliability in the 8 lecture buildings within the UIN Sunan Ampel environment is categorized as reliable, as most of the components in the structural aspect are in good condition.
Reliability in the utilities and fire protection aspect is assessed based on the criteria where a reliability level of 99-100% is considered reliable, 95-<99% is considered less reliable, and <95% is considered unreliable. [3], [10], [12], [18]

The assessment of reliability in utilities and fire protection provides an indication of the health and safety value of a building). The evaluation analysis focuses on the functionality of utilities and fire protection systems, including fire protection systems, vertical transportation systems, electrical installation systems, lightning protection systems, communication installation systems, and plumbing systems. [19]–[21]The percentage of reliability levels is shown in Figure 7.

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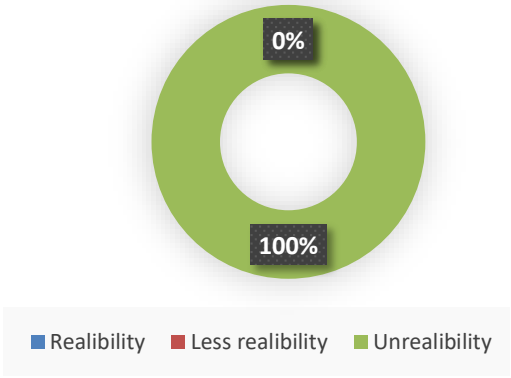

Figure 7. Reliability of utility & fire protection aspects

In terms of the accessibility aspect, the assessment focuses on evaluating the reliability in providing easy access to, from, and within the building, as well as the completeness of infrastructure and facilities for building utilization. The main factors considered in the assessment include the physical condition of the space, pedestrian pathways, the availability of parking areas, the adequacy of equipment and facilities, and the availability and functionality of toilets and doors. The percentage of reliability levels in the utility aspect is shown in Figure 8.

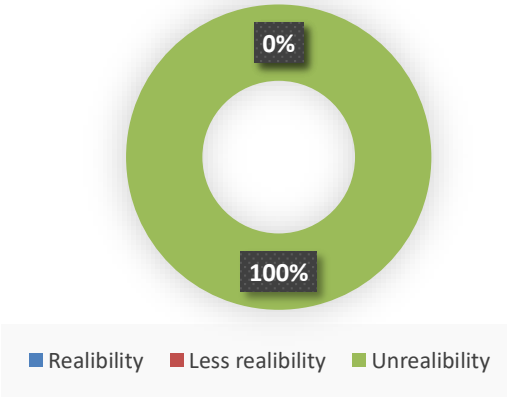

Figure 8. Reliability aspect of accessibility

Based on Figure 8, it can be observed that the reliability level for the accessibility aspect falls into the unreliable category. The reliability values range from 41.50% to 67.05%. The low proportion of reliability is primarily due to poor room conditions such as a lack of parking spaces and the absence of necessary equipment and facilities that should be provided by a building [2], [9], [17].

Regarding the reliability of building and environmental arrangement, the reliability levels are categorized as follows: reliable for a scale value of 95-100, less reliable for a scale value of 75-<95, and unreliable for a scale value below <75. The evaluation of the reliability of the building and environmental arrangement aims to determine the conformity of the building with building and environmental requirements. This includes meeting the basic building coefficients, floor coefficients, and green area requirements. The percentage of reliability levels in the building and environmental arrangement aspect is shown in Figure 9.

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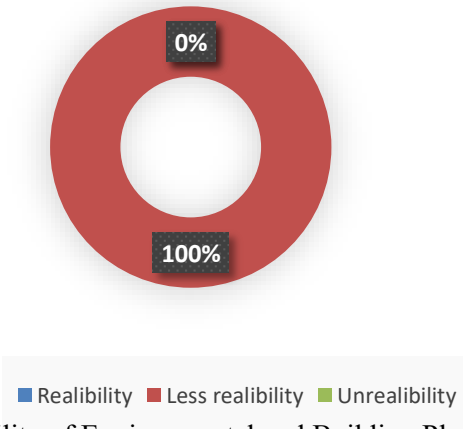

Figure 9. Reliability of Environmental and Building Planning aspects

Based on Figure 9, the observation results indicate that the reliability level in terms of building and environmental arrangement for the 8 observed buildings falls into the less reliable category. The reliability values range from 83.33% to 93.33%. The evaluation results provide information that the lowest component in this aspect relates to compliance with green area requirements.[22]

3.3. Recommendations for Follow-up Actions

Based on field observations and data analysis regarding the types of damage and reliability levels of the lecture buildings within the UIN Sunan Ampel environment, several actions need to be taken to ensure the buildings are in a functional state. Maintenance and care of the buildings should be conducted to obtain the Certificate of Building Fitness (SLF) [5], [17], [23], [24]
Architecture Aspect: From the perspective of architecture, the observation and data analysis results indicate that the lecture buildings within the UIN Sunan Ampel environment are categorized as "less reliable." This means that the buildings can still be functional but require improvement. The recommended follow-up action is rehabilitation, which involves repairing the building's damages to restore its proper functionality.
Structural Aspect: Based on the observation and data analysis of the structural aspect, the buildings can be categorized as "reliable." This means that they can be functional and may also undergo further enhancements.
Utilities and Fire Protection Aspect: The observation and data analysis results show that the lecture buildings within the UIN Sunan Ampel environment are categorized as "unreliable" in terms of utilities and fire protection. This means that the buildings do not meet the health and safety aspects and are not adequately protected against fire hazards. Therefore, it is necessary to consider refurbishment or redesign in this aspect.
Accessibility Aspect: The reliability level of the accessibility aspect of the UIN Sunan Ampel lecture buildings, based on the observation and data analysis, is categorized as "unreliable." This indicates the need for refurbishment and redesign to improve accessibility by adding facilities and infrastructure that ensure easy, safe, and comfortable access, including for people with disabilities and the elderly.
Building and Environmental Arrangement Aspect: The observation and data analysis results, from the perspective of building and environmental arrangement, indicate that the buildings are "less reliable." This means that further action is required to improve and meet the requirements of this aspect.

4. CONCLUSSION

In a review of the type of building damage, lecture buildings in the UIN Sunan Ampel campus environment are categorized as having mild to severe levels of damage. Analysis of the reliability of this building, taking into account the architectural and building aspects as well as the environment,

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classifies the UIN Sunan Ampel lecture building as "less reliable". But in terms of structure, this building is classified as "reliable". Furthermore, taking into account the aspects of utility and accessibility, the building is classified as "unreliable"
Regarding follow-up recommendations, buildings that are classified as reliable must be utilized and their functions improved so that they are reliable. Categories that are less reliable should be used with the necessary repairs, and categories that are classified as unreliable should be redesigned and redesigned. In addition to assessing the level of damage and reliability of the building, it is also important to evaluate the building's maintenance management to ensure that the building remains functional and safe.

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