

Evaluation of the Lightning Protection System at the Khairun University Rectorate Building

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Abstract. Multi-story buildings must be equipped with lightning protection to prevent direct lightning strikes. This study aims to evaluate the lightning protection system in the Khairun University rectorate building using the rolling ball method. The estimated hazard of lightning strikes based on PUIPP is 14, so the Khairun University rectorate building needs SPP. With a height of 27 meters and an efficiency value of SPP $E = 0.22$. Thus, the Khairun University rectorate building is not known for its level of SPP needs. The rectorate building of Khairun University with the rolling ball method has a radius of protection known from the efficiency table for the value of 0.22 does not exist. Thus, the calculation of the radius of the protected area cannot be used. The ground resistance in the Khairun University rectorate building does not meet the PUIL 2000 standard with a standard value of not more than 5 Ohms.

Keywords: Lightning, lightning protection system, grounding.

1 Introduction

The construction of new buildings tends to be multi-story, as a solution due to the narrowness of the land area, but with the increasing number of high-rise buildings, several problems regarding building safety are important to pay attention to, because they are more prone to lightning strikes [1].

Lightning is a very beautiful natural phenomenon, but it is also a threat to living things on earth [2]. As it is known that Indonesia has a tropical climate where the level of thunder days is high every year [3].

Considering that the Khairun University rectorate building is located in a hill area, it is the only tallest building in the area, with its high position making the Rectorate building very vulnerable to lightning strikes. And many benefits can be obtained from the implementation of a lightning rod system to protect electrical, electronic, and other devices which are of course very much needed by the employees of the Khairun University rectorate building. So, the author intends to research the "Evaluation of the Lightning Protection System at the Khairun University Rectorate Building" which already existed before.

2 Literature Review

2.1 Lightning

We often encounter lightning when the rainy season comes. What is called lightning is a blinding flash of

white light, while the thunderous sound that comes after is called thunder. Lightning and thunder came together, but sometimes the time lag between the flash and the roar was short. This difference in arrival time is due to the difference between the speed of sound and the speed of light [4].

2.2 Lightning Damage

Thermal damage is damage that causes fire. Mechanical damage is damage that causes cracked building structures, damaged electronic equipment, and even causes death [3].

2.3 Lightning Protection System

A lightning protection system is a series of protection systems from direct lightning strikes. As is known, the effects and impacts of lightning strikes and lightning protection systems are one way or effort to overcome lightning strikes [3].

3 Research Methods

This research method uses a descriptive method with a quantitative approach which is carried out in the rectorate building of Khairun University for 3 months, starting from January to March 2022.

The steps of this research include 1. Collecting data from various sources and literature to obtain a theoretical basis. 2. Collect building data, data lightning

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rod, conductor data, data grounding, and thunder day data for Ternate City.

After the data has been collected, it is then analyzed using the PUIPP formula and SNI 03-7015-2004.

4 Result and Discussion

4.1 Ternate City Thunder Day Data 2021

Ternate Thunder Day data was obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) of Ternate City Geophysics Station for a period of 1 year, starting from January 2021 to December 2021, obtaining 101 thunder/lightning days.

4.2 Data of Khairun University Rectorate Building

Building height with roof: 27 m
 Building length : 47 m
 Building Width : 47 m

4.3 Lightning protection system data

4.3.1 Air Termination

Type : Copper
 Amount : 1
 Length : 40cm
 Condition: Not working

4.3.2 Grounding

Type: Rod electrode (Steel)
 Diameter : 30mm
 Length : 1.5m
 Planting depth : 1.5 m
 Measuring instrument: Earth Tester Model MS5209

4.4 Determination of Protection Needs to be Based on PUIPP

Determination of building protection needs based on Thunder Day Regarding the index in the formula contained in the PUIPP, conclusions can then be drawn regarding whether or not an external lightning protection system is used, and can be obtained as follows:

Index A, building type: 1 (Graded)
 Index B, building construction: 2 (Reinforced concrete or non-metal roof iron frame)
 Index C, building height: 4 (About 25 meters)
 Index D, building situation: 1 (Hill, less than 1000 meters)
 Index E, days of thunder: 6 (Days of thunder per the year 2021 are around 128)

So from the index above, the estimated lightning strike hazard (R) is:

$$R = \text{Index A} + \text{Index B} + \text{Index C} + \text{Index D} + \text{Index E}$$

$$R = 1 + 2 + 4 + 1 + 6 = 14$$

If $R > 13$ then lightning protection is needed in the building.

The estimated hazard of a lightning strike is 14, as a requirement of $R > 13$, it can be concluded that this building is in dire need of lightning protection.

4.5 Determining The Need for Protection Level Based on SNI 03-7015-2004

4.5.1 Determination of the need for the protection level of the rectorate building for a lightning protection system

Determination of the level of protection needed for an area for a lightning rod system, namely calculations using thunder day data, building size data, protection area, local direct strike frequency (N_s), and annual strike frequency, by first calculating the density of lightning strikes to the ground (N_g).

The density of lightning strikes to the ground (N_g) is affected by the day of thunder in the area. The number of thunder days in Ternate City is around 101.

Then the density of lightning strikes to the ground (N_g) can be calculated by the equation:

$$N_g = 4.10^2 \cdot Td^{1.26}$$

$$N_g = 4.10^2 \cdot 101^{1.26}$$

$$N_g = 13,41 \text{ strikes per km}^2 \text{ per year}$$

Meanwhile, the land surface area which is considered to have an annual direct strike frequency can be calculated as follows:

$$A_s = a \cdot b + 6 \cdot h(a + b) + 9\pi \cdot h^2$$

$$A_s = 2.209 + 6 \cdot (27) (47 + 47) + 9 \cdot 3,14 \cdot 27^2$$

$$A_s = 2.209 + 162 \times 94 + 28,26 \times 729$$

$$A_s = 2.209 + 15.228 + 20.601,54$$

$$A_s = 38.038,54 \text{ m}^2$$

Meanwhile, calculating the average number of direct lightning strikes per year (N_s) can be searched with the following equation:

$$N_s = N_g \times A_s \times 10^6$$

$$N_s = 13,14 \times 38.038,54 \times 10^6$$

$$N_s = 449.826,415 \times 10^6$$

$$N_s = 4,49 \text{ lightning strikes per year}$$

Where :

a = building length (m)

b = Building width (m)

h = building height (m)

T_d = Average day of thunder per year

N_g = Density of lightning strikes to the ground (strikes/Km²/year)

A_s = Area that still has a lightning strike rate of N_s (Km²)

N_s = Frequency of direct lightning strikes per year

N_c = determination (10^6)

The annual frequency of lightning strikes (N_s is known to be 10^6) is permitted. Determination of the level of protection in buildings based on the calculation of N_s and N_c is done as follows :

a. If $N_s \leq N_c$ no need for a protection system

b. If $N_s > N_c$ a protection system is needed

Due to the calculation obtained then the efficiency value

$$E = 1 - \frac{N_c}{N_d}$$

$$E = 1 - \frac{10^{-1}}{4,49}$$

$$E = 1 - 0.022$$

$$E = 0.22$$

Where :

E = Efficiency of lightning protection system

N_d = Frequency of direct lightning strikes per year

N_e = Local permissible annual lightning strike frequency (10^{-1})

Where the relationship between the value of E (efficiency) with the level of protection according to the efficiency table, thus the value of E of 0.22 does not have a level of protection, because the efficiency value of 0.22 is small and does not exist in the table of protection.

4.5.2 Calculation of the protection area of the lightning protection system in the rectorate building of Khairun University

After determining the level of lightning protection, then we will calculate and analyze the area of the protection area for the previously installed lightning distributor. This is done to find out whether the area has been well protected or not. The method used to analyze the protected area is to use the rolling ball method.

For this method, the radius of protection of the rolling ball is known through the table of protection for a value of 0.22 none. So, to find the peak current the equation $R (m) = I^{0.5}$ can not be used. It can be said that the building is not known to be able to withstand the peak lightning current value and it is also not known to be taken up by the lightning dealer if the lightning current value exceeds the peak current.

4.6 Grounding System

The grounding electrode for the grounding system used is a rod-type electrode. The material of this rod electrode is steel which is installed to a depth of 1.5 meters.

$$R_g = R_s \frac{\rho}{2\pi L_R} \left[\ln \left(\frac{4L_R}{A_R} \right) - 1 \right]$$

$$R_g = R_s \frac{100}{2 \times 3,14 \times 1,5} \left[\ln \left(\frac{4 \times 1,5}{0,030} \right) - 1 \right]$$

$$R_g = R_s \frac{100}{9,42} \left[\ln \left(\frac{6}{0,030} \right) - 1 \right]$$

$$R_g = R_s 10,61 [\ln (200) - 1]$$

$$R_g = R_s 10,61 [5,298 - 1]$$

$$R_g = R_s 45,601 \Omega$$

Where:

R_g = Defense resistance (Ω)

R_s = Defensive resistance for single rod (Ω)

ρ = Soil resistivity (Ω) = 100/Clay

L_s = Electrode Length (m) = 1.5 m

A_s = Electrode Diameter (m) = 30 mm

5 Conclusion

1. The estimated hazard of lightning strikes based on PUIPP is 14, as a requirement of $R > 13$, the Khairun University rectorate building needs a lightning rod system.

2. Khairun University rectorate building with a height of 27 meters and an efficiency value of SPP E = 0.22 which is not available in the efficiency table. Thus, the rectorate building of Khairun University is not known to require the level of need for a lightning protection system.
3. Khairun University rectorate building with the rolling ball method the protection radius is known through the lightning protection efficiency table for a value of 0.22 not present. Thus, the calculation of the radius of the protected area cannot be used.
4. The grounding resistance in the Khairun University rectorate building has a grounding value of 45.601 Ohm. Then it does not meet the PUIL 2000 standard with a standard value of not more than 5 Ohms.

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