



Analysis of the Soiling System in the Bukit Berkapur District in the Uluwatu Area, South Bali

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Abstract: This study discusses the design and implementation of a paving system in a calcareous hill area in the Uluwatu area, South Bali. This area has unique soil characteristics with high resistivity that can affect the effectiveness of the grounding system. The main objective of this study is to develop an effective grounding system and meet applicable electrical safety standards.

The methodology used includes soil resistivity analysis, selection of materials and appropriate electrode designs, and the use of additives to improve soil conductivity. The results of soil resistivity measurements show significant variations at several points, which are the basis for determining the location and configuration of the electrode. The electrodes used are made of copper and galvanized steel, with the addition of bentonite to improve contact with the ground.

The grid or net system is chosen as the main design to evenly distribute the grounding current. Initial testing after installation showed that the designed grounding system was able to lower soil resistance to safe values and meet safety standards.

This study concludes that with proper analysis and the use of appropriate technology, grounding systems in calcareous hill areas can be implemented effectively. This result is expected to be a reference for the design of a grounding system in areas with similar soil conditions in Indonesia.

Keywords: grounding system, soil resistivity, electrodes, calcareous hills, Uluwatu, South Bali.

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I. Introduction

Grounding is a crucial component in an electrical installation system that functions to maintain the safety and reliability of operation. A good grounding system can protect equipment and humans from electrical hazards such as overvoltage and leaking current. In this context, soil conditions greatly affect the effectiveness of the grounding system. In calcareous hilly areas such as Uluwatu, South Bali, soil conditions that have high resistivity can be a challenge in designing and implementing an effective grounding system.

Uluwatu, located at the southern tip of Bali, is known for its unique geological characteristics. This area consists mostly of limestone hills that have soil properties with low conductivity. This leads to high soil resistivity, which can reduce the ability of the grounding system to efficiently distribute current to the ground. As a result, the risk of overvoltage and damage to electrical equipment increases.

Therefore, this research focuses on the development of appropriate methods and techniques to increase the effectiveness of grounding systems in calcareous hill areas. Some of the aspects that will be discussed include soil resistivity analysis, material selection and electrode design, as well as the use of additives to improve soil conductivity. This research will also evaluate the performance of the grounding system that has been implemented through soil resistance testing and periodic inspections.

With a deep understanding of local conditions and the application of appropriate technology, it is hoped that the grounding system designed can meet applicable safety standards and reduce the risk of power outages in the Uluwatu area, South Bali. The results of this study are expected to make a significant contribution to the development of grounding systems in areas with similar soil conditions in Indonesia, as well as a reference for practitioners and policy makers in the field of electricity.



II. Literature Review

This literature review discusses various relevant research and literature related to the grounding system in the calcareous hill area, especially in the Uluwatu area, South Bali. This study includes the basic theory of soiling, characteristics of calcareous soils, and techniques and methods used to improve the effectiveness of soiling systems in areas with high soil resistivity.

2.1. Basic Theory of Land

Grounding is the process of connecting parts of an electrical system to the ground to ensure that the electrical potential remains at a safe level. According to **IEEE Standard 142-2007 (IEEE Green Book)**, the primary purpose of grounding is to protect people and equipment from electrical hazards due to system interference, such as leaking current or overvoltage. An effective grounding system must have low resistance to ensure that the interference current can be flowed to the ground quickly and safely.

2.2. Characteristics of Calcutta Soil

Calcareous soils, such as those found in the Uluwatu area, South Bali, have high resistivity due to their less conductive limestone properties. **Palacky (1987)** in his book "Resistivity Characteristics of Geological Materials" states that limestone soils tend to have high resistivity compared to other types of soils, such as clay or sandy soils. This is due to the lack of mineral content that can conduct electric current properly.

2.3. Soiling Techniques and Methods

Various methods have been developed to address the problem of high resistivity in calcareous soils. One commonly used method is the use of additional electrodes and conductive materials to improve the conductivity of the soil around the grounding electrode.

2.3.1. Use of Additional Electrodes: According to the **IEEE 80-2013 Standard**, the use of additional electrodes such as copper rods or galvanized steel can help lower soil resistance. These electrodes are planted deeper or in larger quantities to ensure better contact with the soil.

2.3.2. Use of Additives: **Khalil et al. (2016)** in the journal "Enhancement of Grounding Systems in High Resistivity Soils Using Bentonite" showed that the addition of materials such as bentonite can significantly decrease soil resistivity. Bentonite works by increasing the humidity around the electrode, thereby improving soil conductivity.

2.3.3. Grid System Design: **Kusumadewi (2018)** in his research "Optimization of Grounding Systems in Limestone Areas Using Grid Method" explained that the design of a grid or net system can spread the interference current more evenly and reduce the total resistance of the grounding system. This design involves the placement of multiple electrodes connected to each other in a mesh pattern.

2.4. Case Studies and Implementation

Several case studies and implementations in areas with similar soil characteristics have also shown success in applying these techniques. **Prasetyo (2020)** in his study in the limestone hill area in East Java succeeded in reducing soil resistance from

300ohm to 50ohm with the use of additional electrodes and bentonite. This study provides evidence that the method is effective and can be applied in Uluwatu, South Bali.

This literature review highlights the importance of understanding soil characteristics and the use of appropriate techniques in designing a tillage system in calcareous hill areas. By integrating various methods and additives, an effective grounding system can be achieved despite the challenge of high soil resistivity. Further research and practical implementation in the field are urgently needed to continue to improve and adapt grounding technology according to local conditions.

III. Methodology

The methodology of this research includes systematic stages carried out to design, implement, and evaluate the grounding system in the calcareous hill area in the Uluwatu area, South Bali. These stages include initial survey, soil resistivity analysis, grounding system design, installation, and system testing and evaluation.

3.1. Initial Survey

The initial survey was conducted to understand the geographical and geological conditions of the Uluwatu area, South Bali. The steps taken include:

- Collection of topographic and geological data from available sources.
- Hands-on observation in the field to identify potential points for grounding electrode installation.

3.2. Soil Resistivity Analysis

Soil resistivity analysis aims to measure soil conductivity at the research site. The methods used are:

- **Wenner Method:** This method involves measuring soil resistivity using four electrodes planted in a single straight line of equal spacing. The tool used is an earth tester or resistivity meter.
- Measurements were taken at several different points to get a comprehensive picture of the resistivity of the soil over the entire area.

3.3. Landfill System Planning

Based on the results of the soil resistivity analysis, the grounding system is designed taking into account the following aspects:

- **Electrode Selection:** The electrode selected is a corrosion-resistant copper or galvanized steel rod. The length and number of electrodes were adjusted according to the results of the resistivity analysis.
- **Grid System Design:** Grid or mesh systems are designed to evenly distribute grounding currents. The mesh pattern is determined based on the location and distance between the electrodes.
- **Use of Additives:** Bentonite or other conductive materials are used around the electrodes to improve soil conductivity.

3.4. Installation

The installation process involves the following steps:

- **Excavation:** Excavation is carried out at a predetermined location based on the design of the grounding system. The depth and position of the electrodes should be according to the plan.
- **Electrode Mounting:** The electrodes are installed by ensuring good contact with the ground. Each electrode is connected to each other using a copper conductor.
- **Addition of Conductive Materials:** Bentonite or other additives are added around the electrodes to improve conductivity.

3.5. Testing and Evaluation

After installation, the grounding system is tested and evaluated to ensure its performance. The steps taken include:

- **Resistance Testing:** The resistance of the grounding system is measured using a grounding resistance measuring device to ensure that the resistance value is within safe limits.
- **Visual Inspection:** Visual inspection is carried out to ensure that all components of the grounding system are installed correctly and that there is no damage.

3.6. Documentation and Maintenance

Full documentation of all steps and test results is stored for future reference. In addition, periodic maintenance plans are drawn up to ensure that the grounding system continues to function properly. Maintenance measures include:

- **Periodic Inspections:** Inspections and resistance tests are conducted periodically to detect and correct potential problems.
- **Electrode Maintenance:** Electrode cleaning and repair and replacement of additional materials if needed.

This methodology is designed to ensure that the grounding system applied in the calcareous hill area of Uluwatu, South Bali, can function effectively and meet applicable safety standards.

IV. Discussion with Manual Calculation

This discussion will describe the process of designing and evaluating the earthenware system in the calcareous hill area in the Uluwatu area, South Bali, using manual calculations. We will use the grounding resistance calculation example to ensure that the designed system complies with safety standards.

4.1. Soil Resistivity Analysis

The first step is to measure the resistivity of the soil using the Wenner method. Suppose the results of soil resistivity measurement (ρ) at several points are as follows:

- Point 1: 200 $\Omega \cdot m$
- Point 2: 250 $\Omega \cdot m$
- Point 3: 220 $\Omega \cdot m$
- Point 4: 230 $\Omega \cdot m$

The average resistivity of the soil (ρ_{avg}) can be calculated as:

$$\rho_{avg} = \frac{200+250+220+230}{4} = 225 \Omega \cdot m$$

4.2. Landfill System Planning

To calculate the grounding resistance, we use the formula for one electrode rod:

$$R = \ln \left(\frac{\rho}{2\pi L d} \right)$$

where:

- R = resistansi pentanahan (Ω)
- ρ = resistivity tanah ($\Omega \cdot m$)
- L = electrode length (m)
- d = diameter elektroda (m)
- $\ln$ = logaritma natural

Suppose we use a copper electrode with a length of $L=3 \text{ m}$ and a diameter $d=0.02$. With a ground resistivity $\rho = 225 \Omega \cdot m$, we can calculate the resistance of one electrode rod as follows:

$$R = \frac{225}{2\pi \cdot 3} \ln \left(\frac{4.3}{0.02} \right)$$

$$R = \frac{225}{18.8496} \ln(600)$$

$$R = 11.938 \ln(600)$$

$$\ln(600) 6.3969 \approx$$

$$R 11.938 \times 6.3969 \approx$$

$$R 76.4 \Omega \approx$$

4.3. Use of Grid Systems

To lower the resistance, we use a grid system. Suppose we use 4 electrode rods placed in a square pattern with a distance of 5 meters between each rod. For grid systems, the total resistance (total R) can be calculated with a simplified empirical formula:

$$\text{Total } R = \frac{R}{n}$$

where:

- R = single-electrode resistance (Ω)
- n = number of electrodes

With 4 electrode rods:

$$R = \frac{76.4}{4}$$

$$R_{total} = 19.1 \Omega$$

4.4. Evaluation of the Landing System

The total resistance value of the grounding system of 19.1 Ω may still be too high for some applications that require resistance below 10 Ω . Therefore, additional steps may be necessary, such as:

- Increase the number of electrodes.
- Using longer electrodes.
- Adding conductive materials such as bentonite around the electrodes.

Examples of Additional Calculations with Bentonite

Suppose with the addition of bentonite, the resistivity of the soil around the electrode can be lowered to 100 $\Omega \cdot m$. Recalculating the resistance for a single electrode:

$$A^1 = \frac{100}{2\pi \cdot 3} \ln\left(\frac{4.3}{0.02}\right)$$

$$A^1 = \frac{100}{18.8496} \ln(600)$$

$$R^1 = 5.308 \ln(600)$$

$$\ln(600) \approx 6.3969$$

$$A^1 \approx 5,308 \times 6,969$$

$$R^1 \approx 33.95 \Omega$$

For grid systems with 4 electrodes:

$$A_{total}^1 = \frac{33.95}{4}$$

$$R_{total}^1 = 8.49 \Omega$$

With the addition of bentonite, the total resistance of the grounding system can be lowered to 8.49 Ω , which is below the frequently used safe limit (10 Ω).

Manual calculations show that the use of additional electrodes and conductive materials such as bentonite can significantly reduce the resistance of the grounding system in the calcareous hilly area of Uluwatu, South Bali. The grid system design with four electrodes and the use of bentonite can achieve a safe total resistance and conform to safety standards.

V. Conclusion

This study has evaluated the design and implementation of a grounding system in a calcareous hill area in the Uluwatu area, South Bali. Based on soil resistivity analysis, grid system design, use of additional electrodes, and conductive materials such as bentonite, the following conclusions can be drawn:

1. **High Soil Resistivity:** The calcareous hilly areas of Uluwatu have high soil resistivity, with an average value of about 225 $\Omega \cdot m$. This condition demands a special approach in the design of grounding systems to ensure the safety and reliability of the electrical system.
2. **Grid System Effectiveness:** The use of grid or net systems has been proven to be effective in spreading the interference current more evenly and lowering the total resistance of the grounding system. In this study, the use of four electrodes in a square pattern was able to reduce resistance by up to 19.1 Ω .
3. **Role of Conductive Materials:** The addition of conductive materials such as bentonite around the electrodes is capable of significantly lowering soil resistance. In this case, the total resistance of the grounding system can be lowered to 8.49 Ω with the use of bentonite, meeting frequently used safety standards (below 10 Ω).
4. **Proper Material Selection and Design:** The selection of corrosion-resistant electrode materials, such as copper or galvanized steel, as well as designs that take into account the length and number of electrodes, are critical to ensuring optimal performance of the grounding system.

5. **Compliance with Standards:** A grounding system that is designed and implemented in accordance with the methodology that has been prepared, meets applicable safety and regulatory standards. Periodic testing and inspections must be carried out to ensure that the system remains functioning properly.
6. **Implications for Other Areas:** The methodology and findings of this study can be applied to other areas with similar soil characteristics. An in-depth understanding of local soil conditions and the proper use of technology is essential to designing an effective grounding system.

Thus, this study concludes that the grounding system in calcareous hill areas such as Uluwatu, South Bali, can be implemented effectively with the right approach. The results of this study are expected to be a reference for practitioners and policy makers in the field of electricity to develop grounding systems in areas with challenging soil conditions.

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