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Gravel Expanse of Substation Switchyard Area on the Coast of South Bali

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Abstract

As a security for equipment and people around the substation, a gravel bed is needed. The results of this study are to determine the thickness of the gravel overlay in the switchyard area of the substation with the texture of the regosol soil so that the equipment and people around it are avoided from the current of disturbance that flows when a disturbance occurs, and the results of this study can be useful as a reference for the installation of gravel in the construction of the substation in the location of the regosol soil texture. The method used in this study is to use descriptive quantitative analysis. The results of the study were obtained that the thickness of gravel stones of 0.15 meters to 0.17 meters has the best value in wet and dry conditions in the texture of the regosol soil on the coast of Kuta, the coast of Gianyar and the coast of Klungkung.

Keywords: Gravel Stone Overlay; Regosol Soil; Step Tension; Touch Tension.

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1. Introduction

The surface of the switchyard area is laid with gravel to increase the contact resistance between the ground and the human feet at the substation to avoid the danger of overcurrent. A pebble with a thickness of at least 0.08 meters depending on the texture of the soil [1,2,3,4]. This research is a reflection of the problems faced in the construction of substations on different soil textures in Indonesia. With the variety of soil textures, it is necessary to research the thickness of the gravel that is spread. This study examined the thickness of gravel from 0.08 meters to 0.17 meters thick to the step stress and touch stress on the texture of the regosol soil on the south coast of Bali, namely the Badung, Denpasar, Gianyar and Klungkung areas.

2. Materials and Methods

2.1. Literary Studies

2.1.1 Substation

One of the components of the electric power distribution system as a liaison for consumer electricity services. Substations serve as load regulators and for lowering and raising voltage. High-voltage electrical equipment is power transformers, power breakers, control equipment and protective equipment [5].

2.1.2 Gravel

Gravel is spread over the switchyard area aiming for [6,7,8,9]:

1. As a layer of high resistance between the personnel who step on it and the ground under the gravel. This gravel serves as insulation between the feet of personnel in the area against the ground.
2. The gravel layer on the switchyard surface when there is a disturbance current to the ground, the disturbance current will flow directly into the ground and not along the ground surface area. This can reduce the amount of voltage value at *the Touch Potential* or *Step Potential*.
3. If the transformer leaks, it is hoped that the spread of fire when the oil burns can be avoided and does not disturb other equipment in the area.
4. Inhibits the growth of grass and shrubs in the switchyard area of the substation.
5. The main function is to reduce the magnitude of the touch voltage and the step voltage

2.2 Research Design

The deesain of the research will be used as a reference in conducting research as shown in figure 1 below.

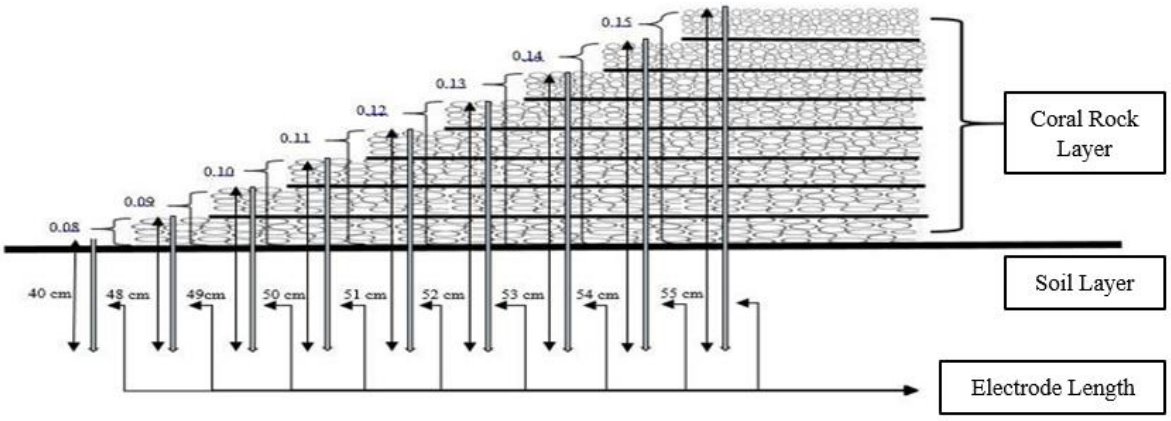

Figure 1: Gravel Thickness 0.08 m – 0.17 m , Electrode Length from 0.4 m – 0.57 m

2.3 Research Chart/Research Flow Diagram

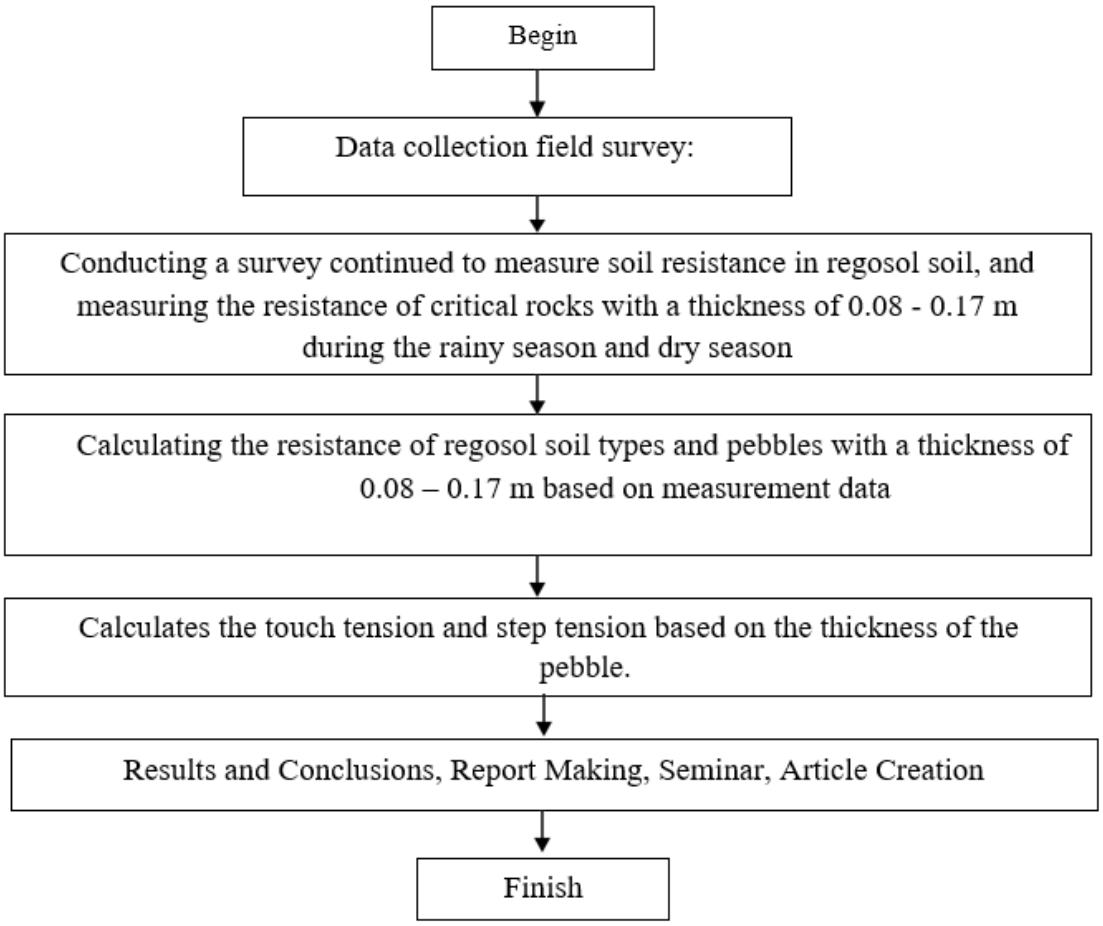

Figure 2: Research Chart/Research Flow Diagram

2.4 Research Data Analysis

Calculation of the contact stress and step stress on the thickness of gravel 0.08 meters - 0.17 meters based

on the equations on the soil and wet and dry gravel conditions.

3. Results and discussion

The results of the measurement of soil resistance in dry and wet conditions as shown in Chart 1.

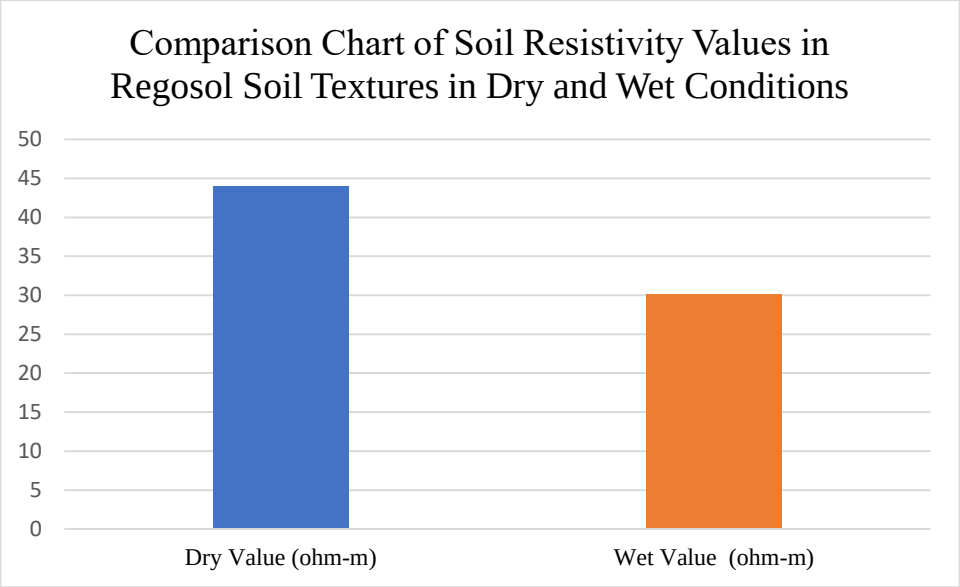

Figure 1: Value Comparison Chart Soil Type Resistance Dry and Wet Soil Condition

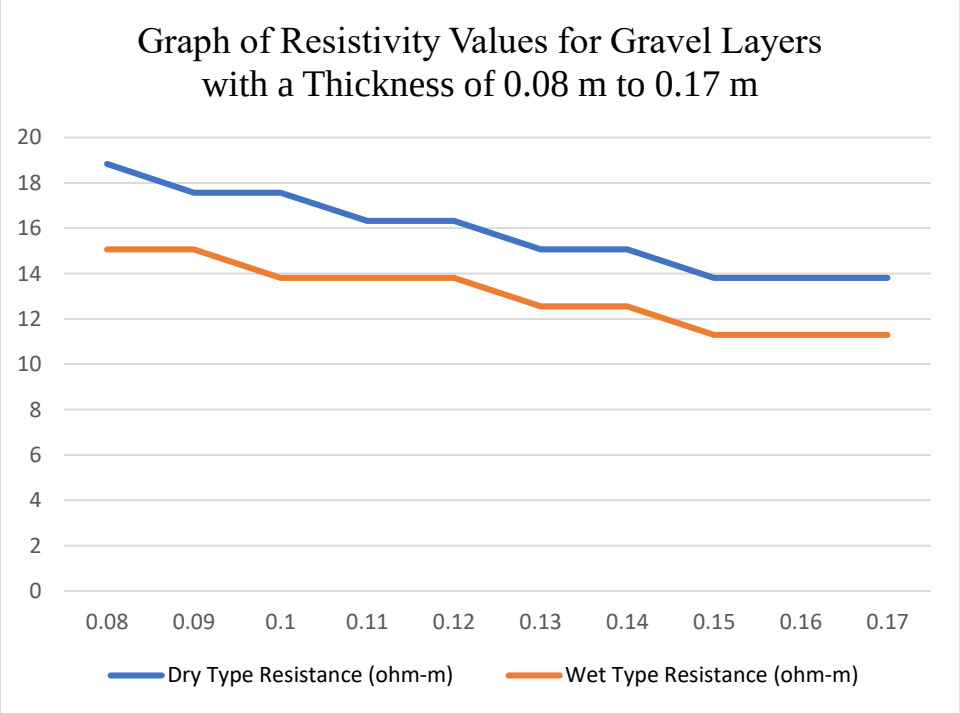

Figure 2: Graph of the Resistance Value of Gravel Types of Thickness 0.08 meters – 0.17 meters On Regosol Soil Texture Wet and dry conditions

3.1 Touch Voltage Analysis

The reduction factor uses the following equation:

$$C_{s\,0,08} = 1 - \frac{0,09\ \left(1 - \frac{\rho}{\rho_s}\right)}{2h_s + 0,09}$$

Up to a thickness of 0.08 meters is obtained,

$$C_{s\,0,08} = 1 - \frac{0,09(1 - \frac{43,960}{18,840})}{2x0.08 + 0,09}$$

$$C_{s\,0,08} = 1,48$$

So the contact tension is obtained based on the thickness of the gravel stone of 0.08 meters in dry soil conditions as follows:

$$E_{t\,70} = [1000 + 1,5\rho_s\ C_s]\ \frac{0,147}{\sqrt{t}}$$

$$E_{t\,70} = [1000 + 1,5\ x\ 18,84\ x\ 1,48]\ \frac{0,147}{\sqrt{1}}$$

$E_{t\,70} = 153,147$ Volt

The results of the calculation of the contact voltage in dry conditions with variations in the thickness of gravel are 0.08 meters to 0.17 meters as shown in table 1.

Table 1: Results of Touch Voltage Calculation Under Conditions Dry with variations in gravel thickness 0.08 meters To 0.17 meters

No t	Dry Regosol Soil Type Resistance $\rho = 2 . \pi . \alpha . R$ (Ohm – m)	Dry Gravel Type Resistance (Ohm – m)	Gravel Thickness (m)	Reduction Factors	Touch Voltage (V)
1	43,960	18,84	0,08	1,48	153,147
2	43,960	17,56	0,09	1,50	152,807
3	43,960	17,56	0,10	1,46	152,70
4	43,960	16,328	0,11	1,49	152,40
5	43,960	16,328	0,12	1,46	152,20
6	43,960	15,072	0,13	1,49	151,90
7	43,960	15,072	0,14	1,46	151,80
8	43,960	13,816	0,15	1,50	151,57
9	43,960	13,816	0,16	1,50	151,57
10	43,960	13,816	0,17	1,46	151,57

The results of the calculation of the touch tension of soil and wet gravel conditions with variations in gravel thickness of 0.08 meters to 0.17 meters are as shown in table 2.

Table 2: Results of Calculation of Touch Stress on Soil Conditions and wet gravel with varying thickness 0.08 meters To 0.17 meters

No	Resistant Wet Regosol Soil Type $\rho = 2 . \pi . \alpha . R$ (Ohm – m)	Wet Gravel Type Resistance (Ohm – m)	Gravel Thickness (m)	Reduction Factors	Touch Voltage (V)
1	30,144	15,070	0,08	1,36	151,52
2	30,144	15,070	0,09	1,33	151,42
3	30,144	13,816	0,10	1,36	151,14
4	30,144	13,816	0,11	1,34	151,10
5	30,144	13,816	0,12	1,32	151,00
6	30,144	12,560	0,13	1,36	151,00
7	30,144	12,560	0,14	1,34	150,70
8	30,144	11,304	0,15	1,40	150,70
9	30,144	11,304	0,16	1,40	150,40
10	30,144	11,304	0,17	1,40	150,40

3.2 Step Stress Analysis

A reduction factor with the thickness of the pebble from 0.08 meters to 0.17 meters is obtained,

$$C_{s\,0,08} = 1 - \frac{0,09(1 - \frac{43,960}{18,840})}{2x0.08 + 0,09}$$

$$C_{s\,0,08} = 1,48$$

The results of the calculation of step tension based on the thickness of gravel on dry sandy clay soils,

$$E_{s\,70} = [1000 + 6\rho_s\, C_s]\, \frac{0,157}{\sqrt{t}}$$

$$E_{s70} = [1000 + 6\, x\, 18,84\, x\, 1,48]\, \frac{0,157}{\sqrt{1}}$$

$$E_{s70} = 183,26 \text{ Volt}$$

Table 3: Results of Step Stress Calculation on Soil Conditions and dry gravel with variations in gravel thickness 0.08 meters To 0.17 meters

No	Dry Regosol Soil Type Resistance $\rho = 2\,.\,\pi\,.\,\alpha\,.\,R$ (Ohm – m)	Dry Gravel Type Resistance (Ohm – m)	Gravel Thickness (m)	Reduction Factors	Step Voltage (V)
1	43,960	18,84	0,08	1,48	183,26
2	43,960	17,56	0,09	1,50	181,80
3	43,960	17,56	0,10	1,46	181,15
4	43,960	16,328	0,11	1,49	179,90
5	43,960	16,328	0,12	1,46	179,40
6	43,960	15,072	0,13	1,49	178,10
7	43,960	15,072	0,14	1,46	177,70
8	43,960	13,816	0,15	1,50	176,50
9	43,960	13,816	0,16	1,50	176,50
10	43,960	13,816	0,17	1,46	176,50

Table 4: Results of Calculation of Step Voltage in Soil Conditions and wet gravel with variations in gravel thickness 0.08 meters To 0.17 meters

No	Resistant Type Wet Sandy Clay Soil $\rho = 2 . \pi . \alpha . R$ (Ohm – m)	Resistant Type Wet Gravel Stone (Ohm – m)	Gravel Thickness (m)	Reduction Factors	Step Voltage (V)
1	30,144	15,070	0,08	1,36	176,30
2	30,144	15,070	0,09	1,33	175,88
3	30,144	13,816	0,10	1,36	174,70
4	30,144	13,816	0,11	1,34	174,40
5	30,144	13,816	0,12	1,32	174,40
6	30,144	12,560	0,13	1,36	173,00
7	30,144	12,560	0,14	1,34	172,80
8	30,144	11,304	0,15	1,40	171,90
9	30,144	11,304	0,16	1,40	171,90
10	30,144	11,304	0,17	1,40	171,90

4. Conclusion

Gravel overlay thickness of 0.08 meters to 0.14 meters for switchyard location Substation on the texture of regosol soil on the coast of South Bali has safe step voltage and touch voltage values, and when gravel thickness 0.15 meters to 0.17 meters has better values according to IEEE std 80-2013 standard.

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