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Research on Assessment of Potential Interference between Individual Grounding Electrodes Using an Electrolytic Tank Modeling Method

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Abstract

This paper deals with the assessment of potential interference between individual grounding electrodes using an Electrolytic Tank Modeling method. When a test current was passed through a grounding electrode, potential rise was measured and analyzed using an electrolytic tank in real time. In order to analyze the potential interference between grounding electrodes, a reduced scale modeling method was studied. Potential interference between isolated grounding electrodes was evaluated as a function of the separation distance between grounding electrodes and the configuration of grounding electrode to be induced. It was found that the separation distance between grounding electrodes was a major factor in reducing the potential interference.

Key Words : Assessment, Potential interference, Electrolytic tank modeling method, Distance

1. Introduction

Grounding plays a pivotal role in maintaining a system stable without malfunction and keeping operators safe. Unfortunately, however, the importance of grounding has often been overlooked. Grounding is classified into two categories: frame grounding to prevent electric shock and functional grounding to stabilize the system.

The question of whether systems or facilities should be grounded individually or all together remains to be determined and many studies have been conducted on this question worldwide. In Korea to date, most businesses have preferred isolation grounding. Recently, however, common grounding has been widely used worldwide. For this reason Korea has also started to adopt common grounding as well. Because communication systems, computer systems, control equipment, medical facilities, and electrical systems have different specifications and voltage, both common grounding and isolation grounding have advantages and disadvantages[1-5]. Therefore, this study has simulated the release of fault current to a ground based on isolation grounding, using an electrolytic tank modeling method to analyze potential rises. The potential

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interference between ground rods / ground rod and metallic conductor was also analyzed. The analyzed data will be used to reduce the electric shock that is caused by ground potential rises and maintain stable facilities.

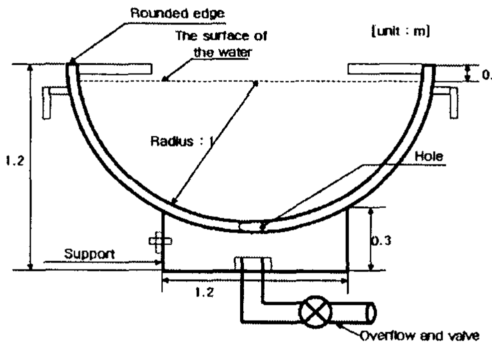
2. Experimental Apparatus and Methods

2.1 Configuration of experimental apparatus

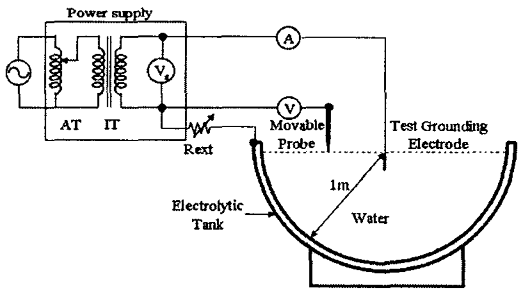
In reality, it is very difficult to get an optimum arrangement after configuring full-scale grounding systems. Therefore, a reduced-scale model has been used for analysis of the grounding systems. Electrolytic tank modeling is used to yield an optimum arrangement that is close to the real grounding systems by analyzing the shape of the grounding electrodes in a homogenous sedimentary structure and the distribution of potential rises. The electrolytic tank modeling method consists of an AC power supply that constantly generates ground fault current, a transfer potential analysis system that measures traces of measuring point and ground potential rises, electrolytic tank, and test electrodes. The electrolytic tank and measuring circuits used in the electrolytic tank modeling method are stated in Fig. 1.

The electrolytic tank was made of stainless steel with a diameter of 2[m]. The tank was grounded to prevent electric shock, stabilize the system, and eliminate noise. In consideration of safety and separation of fault current (220[V]), an insulated transformer was used. An AT (Auto Transformer) was included for change of fault current. The variable resistance in Fig. 1 (b) was set to 6.04[Ω] and installed to restrict current when ground fault current occurred at the AC power supply.

A voltage meter that gauges applied voltage was used to simulate voltage between the test electrode and an infinite point. Therefore, this refers to the ground potential between the probe and infinity. The current meter refers to the current between the test electrode and an infinite point. The grounding resistance of grounding electrodes buried in the ground (V/I ratio) was then obtained[6-8].



(a) Electrolytic tank



(b) Measuring circuit

Fig. 1. An electrolytic tank modeling method

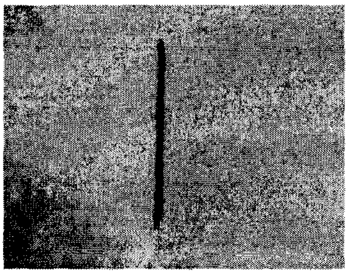
A probe that measures ground potential was installed in a transfer potential analysis system to measure potential on the surface of and inside water. It was transferred through a conveyor and the transfer traces of the probe were displayed in a potential measuring system. The motor speed range of a potential analysis system is from 0 to 0.01[m/s]. The probe was made of 5.1[mm] copper rod. It was tightly locked to prevent any rattling or movement during transportation. Water resistivity at measurement reached 37[Ω/m] by CM-21P (Japan).

2.2 Experimental methods

A full-scale model and a one-fiftieth reduced-scale model are shown in Table 1 below while Fig. 2 shows the grounding rods and ground-buried metallic conductors used in the experiment.

Table 1. A full-scale model and a one-fiftieth reduced-scale model

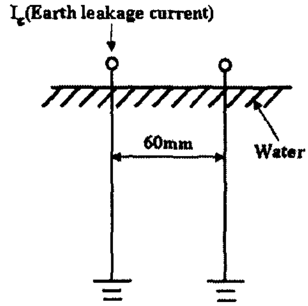
Category \ Model	Full-scale Model	Reduced-scale Model
Buried Depth of Grounding Electrode	0.75[m]	15[mm]
Length of Grounding Rod	1[m]	20[mm]
Diameter of Grounding Rod	0.0127[m]	1[mm]



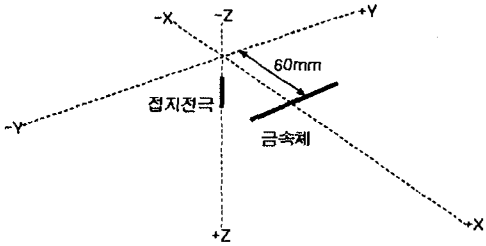
(a) Grounding rod

(b) Underground buried metallic conductor

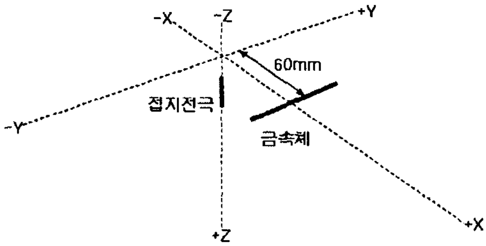
Fig. 2. Test grounding electrode and metallic conductor



(a) Potential interference between grounding electrodes



(b) Potential interference with a vertical metallic conductor

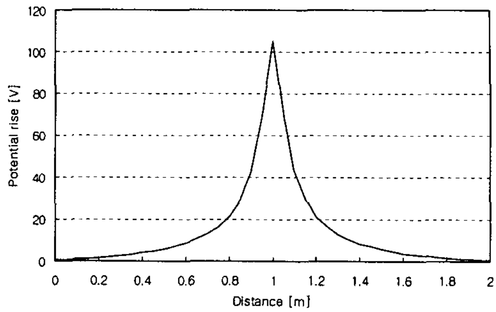


(c) Potential interference with a horizontal metallic conductor

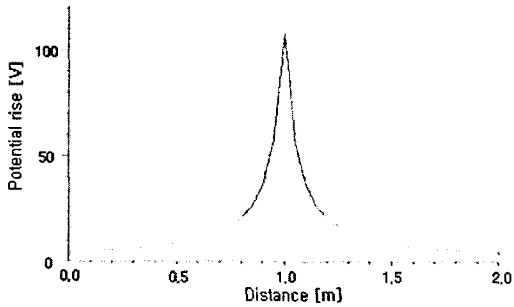
Fig. 3. Arrangement of grounding electrode and metallic conductor

To simulate soil, a tank was filled with groundwater. For convenient test and prevention of erosion, the test electrodes were made at a reduced-scale model of one-fiftieth with 1[mm] stainless conductor. The test electrodes were installed 15[mm] below the water surface because the Technical Standards of Electrical Equipment regulates that grounding electrodes should be installed in the ground at 0.74[m] or more below ground level. This value was adjusted to a reduced-scale model of one-fiftieth. The test electrodes were installed 15[mm] under the water surface in a tank and ground fault current was supplied to the middle of the test electrodes. A probe was then transferred to the tank and potential rises were measured on a realtime basis.

After installing other homogenous grounding electrodes and metallic conductors around grounding electrodes that were 60[mm] distant from each other as shown in Fig. 3, ground fault current was supplied to the grounding electrodes and the effects of the neighboring metallic conductors were analyzed. A 100[mm]-long and 2[mm]-wide copper rod was used for the metallic conductor around the grounding electrodes. The effect of potential interference was measured by keeping the rod vertical and horizontal against the moving direction of the probe and 60[mm] away from the grounding electrodes.



(a) Experimental value



(b) Calculated value by program

Fig. 4. A comparison of experimental and calculated values

3. Results and Discussion

3.1 Comparison of experimental and calculated value

To verify the feasibility and accuracy of the experimental results, they were compared with calculated results that were obtained using CDEGS. The result is shown in Fig. 4 below:

A stainless ground rod (1[mm] in thickness, 100[mm] in length) was used as a grounding electrode in this experiment. After installing this rod in the middle of an electrolytic tank, ground fault current was supplied and potential rises were analyzed. Through this experiment, the feasibility and reliability of the experimental values were verified and the test results will be used in proposing the grounding systems that are necessary in establishing safe electrical facilities.

3.2 Potential interference between ground rods

Isolation grounding is a way to ground individually. If there are two grounding electrodes, for example, isolation grounding will be ideal when the grounding current flows in the grounding electrode on one side; no potential rise occurs on the grounding electrode on the other side, as shown in Fig. 5 below. Unless the two grounding electrodes are infinitely isolated, they would not be independent to each other[9].

In reality, if potential rises reach a certain level, they are completely isolated from each other. The distance is dependent on three factors: the maximum value of grounding current, the permissible value of ground potential rises, and ground resistivity.

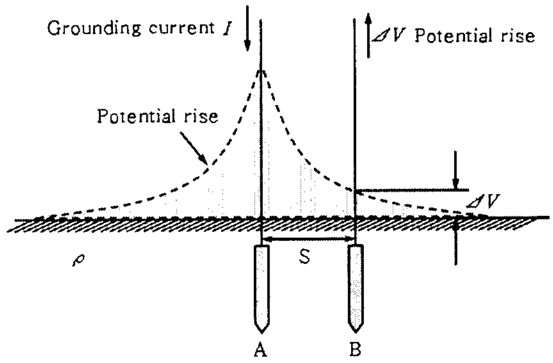


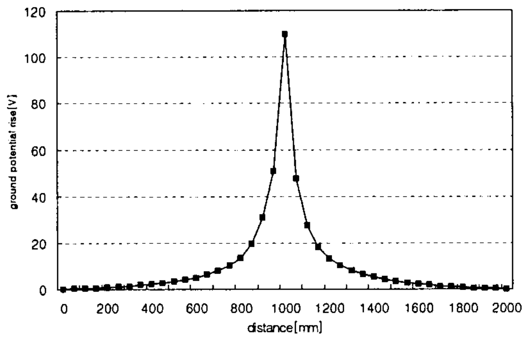
Fig. 5. Potential interference between grounding electrodes

Potential interference means that grounding electrode B is interfered with by the potential rises of grounding electrode A. As a gauge that evaluates the influence of the potential interference on grounding electrode B, potential interference coefficient K can be defined as follows[10]:

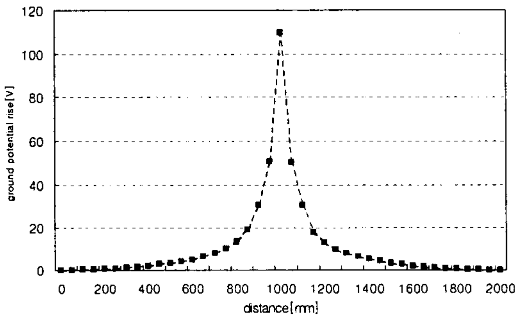
$$K=\frac{\text{Potential of Grounding Electrode B}}{\text{Potential of Grounding Electrode A}} \quad (1)$$

When the ground rod is isolation-grounded at 60[mm] and 100[mm], the ground potential will have a symmetrical distribution centering at 1,000[mm] as shown in Fig. 6 (a). The applied voltage is then 246[V] with an applied current is 0.5[A]. The maximum value (110[V] per 0.5[A]) was observed at 1,000[mm] when grounding electrodes were in position with the flow of ground fault current.

When two points (at 1060[mm]: homogenous grounding electrodes are installed, at 940[mm]: no symmetrical electrode is available) were compared, a mild ground potential rise (about 3[V]) was observed at 1,060[mm]. The potential interference coefficient between grounding electrodes turned out to be 0.432 according to Equation (1). As shown in Fig. 6 (b), no potential interference between grounding electrodes was observed at 100[mm] of distance. When two points (at 900[mm] and at 1,100[mm]) were compared, 0.2[V] of potential difference was observed. Further, the potential interference coefficient turned out to be 0.277 at 100[mm] of distance. Therefore, if other grounding electrodes exist near the grounding electrode, the separation distance increased and the influence of potential interference decreased accordingly.



(a) 60(mm) of distance

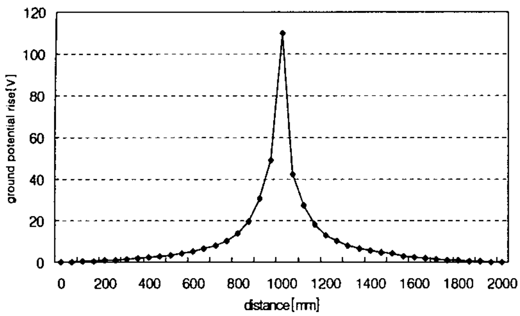


(b) 100(mm) of distance

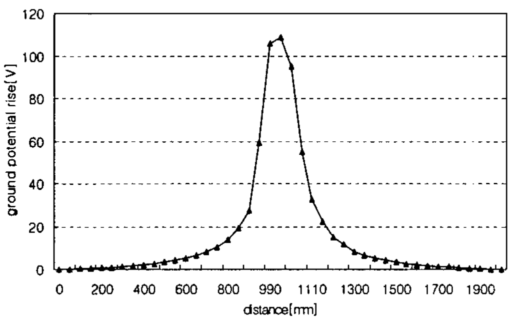
Fig. 6. Potential interference between ground rods

3.3 Potential interference between grounding electrodes and the underground buried metallic conductor

Fig. 7 shows the distribution of grounding potential when a metallic conductor that is buried 60[mm] away from a grounding rod is found.



(a) Potential interference with a vertical metallic conductor



(b) Potential interference with a horizontal metallic conductor

Fig. 7. Potential interference between a ground rod and a metallic conductor

As shown in Fig. 7 (a), when a metallic conductor was buried vertically, the ground potential was approximately 6.8[V] lower than the level when no metallic conductor was available. However, the applied voltage and applied current turned out to be the same as the potential interference between grounding electrodes while the potential interference coefficient turned out to be 0.386. Fig. 7 (b) shows the case in which horizontal metallic conductors are buried. When these two cases were compared (i: the metallic conductor was not buried (between 890[mm] and 990[mm]), ii: metallic conductor was buried (between 1,010[mm] and 1,110[mm]), the ground potential distribution was low and moderate in the latter when the metallic conductor was buried. At a distance of 60[mm], on the contrary, the potential interference coefficient was 0.5, which means that the potential interference has more influence than the vertical metallic conductor.

As shown in Fig. 7, if a metallic conductor exists near grounding electrodes, ground potential is decreased. In order for grounding electrodes to be free from interference, a sufficient distance of separation should be ensured to avoid potential rises in grounding electrodes on the other side, even though ground fault current is supplied to the grounding electrodes on one side. However, in actuality, it is difficult to maintain a long distance. Therefore, it is necessary to take into consideration the surroundings and neighboring facilities during the grounding process.

4. Conclusion

This paper has analyzed and evaluated the potential interference between ground rods / ground rod and metallic conductor using an electrolytic tank modeling method. As a result, the following conclusions have been found:

(1) An electrolytic tank modeling method was used for easy analysis of grounding systems, which are essential to protect operators and maintain facility stability. Further, by comparing experimental and calculated values, feasibility and reliability have been secured.

(2) In terms of potential interference between ground rods, if the separation distance between the grounding electrodes becomes longer, the influence of potential interference decreases. When other grounding electrodes were installed near the primary grounding electrode, the potential rise was weaker than when they were absent.

(3) In terms of potential interference between ground rod and metallic conductor, potential

interference turned out to be more influential in horizontal metallic conductor than vertical metallic conductor because horizontal metallic conductor is closer to the grounding electrodes through which ground fault current flows than vertical metallic conductors. The ground potential distribution turned out to be lower and more moderate when metallic conductors are buried than when they are not buried.

The results of this paper can be used in determining an optimum grounding system in single soil. Based on the modeling technique, further research will be conducted on the development of grounding system safety assessment technology in terms of dangerous voltage.

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