Investigation on the Spot for Grounding Systems in Buildings

Hyoung-Jun Gil* · Dong-Woo Kim · Dong-Ook Kim · Hyang-Kon Kim

Abstract

This paper deals with investigation on the spot for grounding systems of buildings based on international standards at construction sites. The investigation was carried out for grounding method, grounding type, shape of grounding electrode, grounding for a lightning protection system, continuity of steelwork in reinforced concrete structures, etc. The investigation on the spot was performed by a researcher and engineer with over fifteen years of industry experience all over the country. As a result of the investigation on the spot in 13 buildings, common grounding and structure grounding methods were dominant. The safety improvement methods include installation of equipotential bonding conductors for the connection to the main earthing terminal, equipotential bonding conductors for supplementary bonding, use of Surge Protective Devices (SPD), and safe connections between earthing conductors and the rebar.

Key Words : Investigation, Grounding System, International Standards, Continuity

1. Introduction

Grounding technology has continued to develop along with the advancement of electronic equipment and social systems. As electronic equipment, which is the basis for a modern social system, becomes more common, many electrical, IT and communication engineers have started to agree that earthing technology should be systematically adopted.

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The term 'grounding' means a low-impedance metallic connection to a properly designed ground grid, located in the earth for safe use of electrical energy. The connection terminal with the ground is called the 'grounding electrode.' If ground fault current or lightning surge current flows into the grounding electrode, a potential rise takes place, which in turn causes various problems such as electric shock, system damage, noise or malfunction. Except in particular cases, the Korean government has forced electrical equipment and devices to be grounded in accordance with the Electrical Equipment Technical Standard. As buildings become higher and larger after international standards were adopted as domestic industrial standards, a new grounding method called 'structure grounding' has been reviewed regarding reasonable earthing for a lightning protection system. In fact, the structure grounding, which makes all groundings in public use in a building, has been actively promoted [1-3].

Therefore, this paper has investigated and analyzed the improvement models of the grounding system based on the Electrical Equipment Technical Standard and international standards through a field inspection on grounding methods, grounding types, shape of grounding electrodes, grounding for a lightning protection system, grounding system-steel reinforcement connection methods and electrical continuity of steelwork in reinforced concrete structures against large buildings under construction in 13 areas including Seoul, Gyeonggi, Gangwon and Gyeongsang. The construction of an earthing system and the electrical continuity of reinforced bar structures have been analyzed through field inspections. This paper has attempted to use the results of the analysis as a safety assessment technique of the earthing system.

2. Research Method

To analyze an earthing system, a field inspection has been carried out against large buildings under construction across the nation including Seoul, Gyeonggi and Gyeongsang. To propose an improved model of a new grounding system which meets international standards after securing practical empirical data, a field inspection team which includes professional researchers and engineers with more than 15 years of work experience at KESCO (65 branches nationwide) has been organized, and a scientific investigation has been performed from December 2008 to March 2009. The field inspection will continue to determine the current conditions of construction sites and induce improvements. The subjects of the investigation on the current conditions of an earthing system include grounding method, grounding type, shape of grounding electrode, grounding for a lightning protection system and electrical continuity of steelwork in reinforced concrete structures against large buildings under construction. Fig. 1 below demonstrates the safety assessment process of a grounding system through field inspection. For this, a field inspection team has been organized. Based on the results of the field inspection, grounding type, whether or not equipotential bonding is applied and electrical continuity have been analyzed. Then, a solution has been suggested to reduce dangerous voltage.

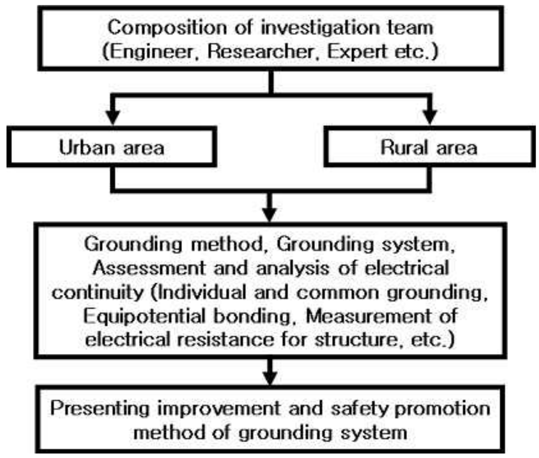


Fig. 1. Investigative and analytical process of a grounding system

3. Field Inspection and Assessment of the Electrical Continuity of a Structure

3.1 Investigation of the Construction of a Grounding System

The fundamental goal of the grounding of electrical equipment is to keep engineers safe from electric shock and the equipment and facilities in good operating condition. The grounding system consists of electrical equipment, grounding electrodes and ground wire.

In terms of use by grounding method such as individual, common and structure grounding, structure grounding has been the most widely used (53[%]) in large buildings, compared to individual grounding (8[%]), 1st– and 2nd–class common and 3rd– class individual grounding (8[%]) and 1st–, 2nd – and 3rd –class common grounding (31[%]). Here, individual grounding refers to separate grounding by facility, while common grounding means connection of individual ground wires and common grounding from the beginning. However, it is different from steelwork in reinforced concrete structures.

Structure grounding mostly refers to the use of conductive matters (ex: steel pipes, steelwork, metallic water pipes, etc.) buried underground, which are not intended to be grounded as a substitute for grounding electrodes.

As shown in Figure 2, 1st–class and 2nd–class common grounding and 3rd–class individual grounding are often found on the construction site. According to the measurement of grounding resistance using the fall-of-potential method, 1st–class and 2nd–classs common grounding (3.7[Ω]) and 3rd–clas grounding (3.71[Ω]) were almost the same. In fact, grounding electrodes have been used all the same time.

According to IEC standards, a grounding system is divided into TT, TN-S, TN-C and IT systems. Under the TT system, the neutral point is directly grounded at the power side. The exposed conductive area is connected to the grounding electrode in the system grounding and electrically independent grounding electrode. In TN-S, a protective conductor and solid conductor are completely separated. The exposed conductive parts, such as equipment enclosures, are connected to the protective conductor which is, in turn, connected to the grounding point of the neutral conductor. In TN-C system, the exposed conductive parts are connected to the protective conductor, neutral conductor and common conductor. In the IT system, on the contrary, either earthing to the ground using high impedance or a non-grounding method is used. According to the field inspection, TT was widely used (77[%]), compared to TN-S (23[%]).

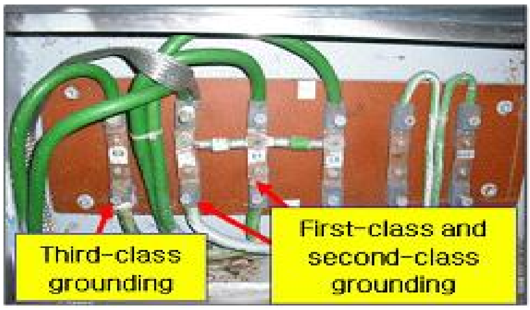


Fig. 2. Example of a grounding terminal

With regard to the grounding for a lightning protection system, the IEC 62305 standards require that it should be commonly used with the grounding for a power system. In large buildings on the construction site, non-common grounding (54[%]) is slightly more preferred to common grounding (46[%]). In other words, separate grounding for a lightning protection system and the power system is still more common. Figure 3 below illustrates the common and non-common grounding between a power system and lightning protection system.

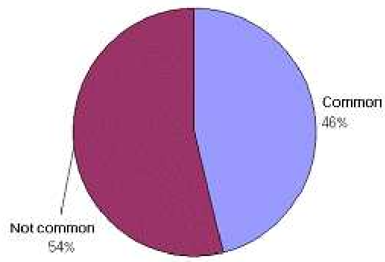
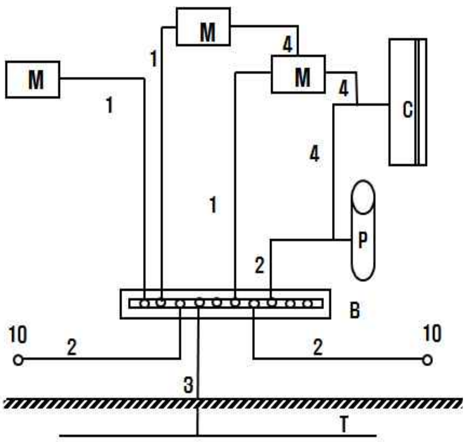


Fig. 3. Condition of common grounding between a power system and lightning protection system

3.2 Analysis of the Construction of Equipotential Bonding

Equipotential bonding means an electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential.

Equipotential bonding for low-voltage circuit facilities includes main and auxiliary equipotential bonding. In the lightning protection system, it refers to the connection by a conductor which reduces spark discharge caused by a lightning current and electric potential difference against conductive parts and metallic, electrical and communication facilities such as structural members (ex: reinforcing bars and steelwork), ducts and elevators. Figure 4 below shows the configuration of equipotential bonding [4].

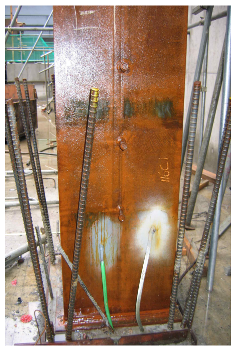


1 : Protective conductor(PE)
B : Main earthing terminal
2 : Equipotential bonding conductor for the connection to the main earthing terminal
M : Exposed conductive part
3 : earthing conductor
C : Extraneous conductive part
4 : Equipotential bonding conductor for supplementary bonding
P : Metal pipe of water pipe, gas pipe etc.
10 : Other equipment
T : Earth electrode

Fig. 4. Configuration of equipotential bonding

At present, the grounding system in Korea includes a protective conductor and ground wire in the main grounding terminal. However, the conductors for main and auxiliary equipotential bonding are hardly found. Figure 5(a) shows an example of equipotential bonding among metal tubes or between a metal tube and an exposed conductive part.

(a) Equipotential bonding



(b) connection between ground wire and steelwork

Fig. 5. Installation of equipotential bonding

For the connection of ground wire with steelwork and reinforcing bars, crimp sleeve, a part of clamp connections, and exothermic welding are available.

According to IEC standards, it is required to secure electrical continuity through a clamp connection or welding. It is also recommended to prevent corrosion between hetero-metals. Figure 5(b) shows a connection between ground wire and steelwork using auto welding. The field inspection has revealed that welding (69[%]) is widely preferred to clamping connection (31[%]) in connecting large buildings.

In the case of water-supply facilities, a gravity tank system and pressurized water-supply system are available. Recently, the latter has been mostly preferred to the former. Under the pressure water-supply system, the power line should be bonded using SPD to protect an inverter. Figure 6 below illustrates water-supply method and the use of SPD.

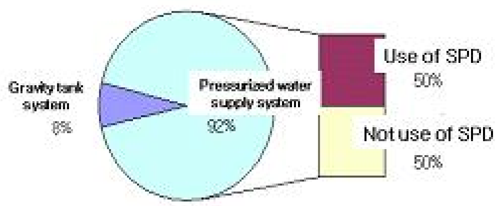


Fig. 6. Condition of water-supply facilities

3.3 Assessment of Electrical Continuity of Steelwork in Reinforced Concrete Structures

If horizontal and vertical bars are tightly connected through welding or other methods, it can be said that steelwork in a reinforced concrete structure has electrical continuity. The vertical bars should be connected through welding, clamp connection, auxiliary connection line-used connection or other qualified methods.

Whether or not the vertical bars in reinforced concrete structures have electrical continuity is decided based on the electrical measurement between the uppermost and ground levels. The electrical resistance for the entire length should be 0.2[Ω] or less. If the electrical resistance exceeds 0.2[Ω] or cannot be measured, the steelwork should not be used as a down conductor of the natural structural member. Instead, it is desirable to install an external down conductor.

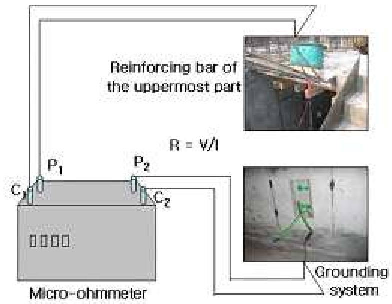


Fig. 7. Continuity assessments in reinforced concrete structures

Table 1. Electrical resistance in reinforced concrete structures

Category / Type	Dimensions [m]			Electrical Resistance[Ω]
	Length	Width	Height	
Office Building	64	29	11	–
Apartment - A	20	20	45	0.182
Apartment - B	50	10	42	–
Apartment - C	36	13	43	0.14
Apartment - D	55	15	90	–
Apartment - E	55	15	90	–
Boarding Building	1000	50	24	0.011
Distribution Complex - A	113	67	47	0.013
Distribution Complex - B	113	67	47	0.02
College Dormitory	30	50	70	0.109
Welfare Center	47	36	20	–
Pumping Station	13	25	16	–
Intelligent Building	30	37	92	0.044

If reinforcing bars are connected using tire wires, in addition, physical damage may take place when a strong current, such as lightning, flows. Therefore, they should be connected under the following methods such as crimp sleeve or exothermic welding.

The electrical continuity of reinforced concrete structures has been assessed after measuring the electrical resistance between the reinforcing bar in the uppermost part and the grounding system on bottom as shown in Figure 7 above. For the measurement, a micro ohm meter (C.A 6250, France) has been used by imposing 0.2[A] or higher current based on the continuity measurement method for protective conductors in KS C IEC 60364 [5-7].

The assessment on the electrical continuity of reinforced concrete structures has been carried out in a pumping station and apartments, intelligent buildings and a distribution complex on the construction site. Table 1 demonstrates the size and electrical resistance of buildings by type. As shown in Table 1, a building has structure grounding if the electrical resistance of the reinforced concrete structure is measured. If the electrical resistance is not measured, on the contrary, a building has no structure grounding. In terms of decreasing the risks of dangerous voltage and improving facility safety, it is desirable to have equipotential bonding in conductivity using structure grounding [8-10].

4. Conclusion

In this paper, a field inspection has been performed on the grounding system on a construction site to investigate and analyze the improvement models of the grounding system. As a result, the following conclusions have been obtained:

(1) More than a half of the inspected buildings had structure grounding, and 46[%] had grounding for a lightning protection system and power system. In terms of equipotential bonding, there has been no conductor for main equipotential bonding. In some construction sites, the conductor for auxiliary equipotential bonding was in use.

(2) In terms of the assessment on the electrical continuity of reinforced concrete structures, it was impossible to measure it in buildings without structure grounding. In buildings where structure grounding was installed, electrical resistance did not exceed 0.2[Ω], satisfying international standards. Because of the recent introduction of international standards, it appears that there will be many changes in facility conditions. To meet the international regulations and secure facility safety through the reduction of dangerous voltage, it is required to establish an integrated grounding system using equipotential bonding and structure bonding.

For assessment on the electrical safety of grounding systems, field inspections and measurements will continue. Based on the results of the inspections, a new grounding system assessment technique will be developed as well.

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