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RESEARCH ARTICLE

Practice of Electrical Insulation of Lightning Protection Systems in India – Before and After the Publication of the National Building Code of India 2016

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Highlights

- This work reviews the installation of ELPS before and after the publication of the National Building Code of India 2016 (NBC).
- This is limited only to ELPS and Internal Lightning protection system (ILPS) is not considered.
- the building was completed prior to the publication of the National Building Code of India 2016; consequently, separation distance and equipotential bonding were not practiced.
- Separation distance is not maintained, however insulated down-conductor after test joints, equipotential bonding with the power line and ring earth will increase the safety of people in the event of a lightning strike.
- RCC columns have been used as a down conductor with a superimposed continuity conductor. In this installation separation distance need not be considered also and equipotential bonding has been done on every floor.

Abstract

Lightning protection system (LPS) as per IS/IEC 62305 is mandatory in India for buildings above 15 meters and for special buildings like educational institutions, and hospitals regardless of their height. External LPS (ELPS) can be of isolated or non-isolated type depending upon the nature of the structure. This paper reviews the installation of ELPS before and after the publication of the National Building Code of India 2016 (NBC). This is limited only to ELPS and Internal Lightning protection system (ILPS) is not considered. The installation has been studied as per IS/IEC 62305 on electrical isolation. The conclusion has been drawn based on the installation and the influence of NBC 2016.

***Keywords** : Lightning Protection System, Separation Distance, Non-Compliance, IEC 62305.*

Introduction

Lightning is a natural hazard which is ubiquitous that occurs across the globe, posing a threat to human beings, livestock, electrical & electronic equipment, buildings & structures etc., and even disturbs the ecosystem by triggering wildfires [1]. In order to mitigate the loss of human lives, livestock and property damage due to lightning, a technical committee TC 81 under International Electrotechnical Commission (IEC) was established in June 1980 in Stockholm, Sweden. The scope of IEC TC-81 is to prepare international standards and guides for lightning protection of structures and buildings, as well of persons, installations, services and contents based on the results of scientific research. The standards set by TC 81 are published in the

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International standard series IEC 62305. The standard for lightning protection system i.e., IEC 62305 has been divided into five parts. IEC 62305-3 provides the requirements for protection of a structure against physical damage by means of a lightning protection system (LPS), and for protection against injury to living beings due to touch and step voltages in the vicinity of an LPS. It consists of two parts namely external protection system and internal protection system. The external LPS can be made as isolated or non-isolated LPS [2]. For an external LPS isolated from the structure, the air termination and down conductors are placed such that the path of the lightning has no contact with the structure. One of the methods for isolating the LPS is done by electrical insulation [2]. This insulation should be large enough to avoid dangerous sparking between the conductive parts of the structure and the LPS. This electrical insulation can be achieved by providing a separation distance, s, between the conductive parts of the LPS and metallic installations in/on the structure [2]. The insulator can be of air, wood or concrete and the separation distance will be influenced depending on the insulation material has been referred from [1]. Generally, the separation distance is not considered in isolated LPS in India.

Legal Requirements of LPS in India

The Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulation which was released in 2023 now requires lightning protection as per IS/IEC 62305 for all buildings taller than 15 metres and buildings like hospitals, airports, schools, and other special places must also have lightning protection, irrespective of their height has been stated in [4].

National Building Code of India 2016 and natural components

Even though the use of natural components was recommended in IS/IEC 62305, architects and civil engineers started accepting the use of natural components as downconductors after the publication of the National Building Code of India in 2016 as stated in [3]. As of 2023, nearly all high-rise structures use RCC columns as lightning-down conductors.

Usage of non-isolated and isolated LPS

It is ideal to have non-isolated external LPS for a structure in India since steel is used commonly in building construction either in RCC columns, PEB columns or in per-cast construction. The external LPS shall be isolated from the structure only if the structure can be damaged by the thermal or explosive effects at the point of strike, on the lightning current-carrying conductor, for example, structure with combustible walls or in places with risk of fire as said in [2]. In India, however, due to the fear of lightning, sometimes isolated LPS is considered for structures ignoring separation distance. As a result, these installations have not been carried out in accordance with IS/IEC 62305.

Separation distance

The separation distance is maintained to avoid lighting current from flowing through metal structures in the building. For isolated external LPS, equipotential bonding is done only at the ground level. For an isolated LPS, the separation distance will be larger on top of the building and negligible at the earth termination system, figure 1 shows a typical installation for an isolated LPS with separation distance.

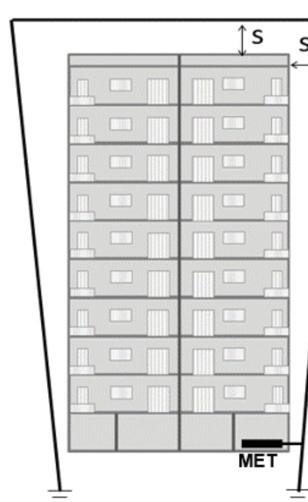

Fig. 1. Separation distance

The simplified formula for separation distance from IS/IEC 62305-3

$$s = (Ki/Km) \times Kc \times l \quad (1)$$

where,

K_i = factor for the class of LPS, higher lightning current results in a higher separation distance.

Table 1. K_i values

Coefficient Ki	
LPL	Ki
I	0.08
II	0.06
III & IV	0.04

K_m = factor depends on the electrical insulation material.

Table 2. K_m values

Coefficient Km	
Type of Material	Km
Air	1
Concrete, Wood, brick	0.5
Select the most un-favorable material	

K_c = Factor depends on the amount of current division on an LPS system.

Table 3. K_c values

Coefficient K_c	
Number of down conductors (n)	K_c
1 (only in case of isolated LPS)	1
2	0.66
3 and more	0.44
Type A earthing – If the value of nearby earth pits does not differ by more than 2. Otherwise, use K_C=1	

l = length of the air termination and down-conductors

Using the Separation Distance equation (1) table IV and a graph have been created, l is the height of the building, and the separation distance of each level of protection has been calculated. In this, only a simplified approach and air as insulation material has been considered, and the number of down conductors is 3 and above.

Note: If the separation distance needs to be wood or concrete the values mentioned in table 4 should be multiplied by a factor of 2.

Table 4. Separation distance on a structure

l (m)	LPL III & IV(m)	LPL II (m)	LPL I (m)
110	1.936	2.904	3.872
100	1.76	2.64	3.52
90	1.584	2.376	3.168
80	1.408	2.112	2.816
70	1.232	1.848	2.464

60	1.056	1.584	2.112
50	0.88	1.32	1.76
40	0.704	1.056	1.408
30	0.528	0.792	1.056
20	0.352	0.528	0.704
10	0.176	0.264	0.352
1	0.0176	0.0264	0.0352

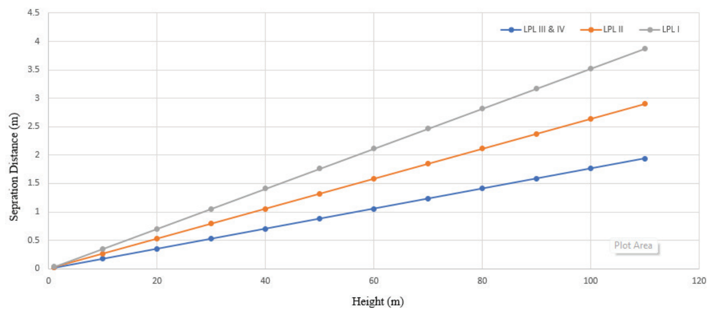

Fig. 2. Separation distance as per LPL

Observation and discussion

For this paper, three cases have been considered.

Case 1: Down conductor through a building in an electrical shaft

An installation has been studied in a 28-story residential building in Chennai with 4 apartments on each floor which was constructed in 2010. The down conductors pertaining the ELPS were observed to have been routed through the electrical shaft and an insulated copper strip has been used.

It was identified that the following subjects have been ignored from the perspective of lightning protection in this building:

- distance between the down conductor
- Equipotential bonding with incoming metallic services (power line)
- separation distance

A portion of the down conductor has been stolen.

Installation photos:

Fig. 3. Insulated copper strip through the electrical shaft

Fig. 4. Cut piece of down conductor in shaft

Fig. 5. Down-conductor from the terrace

Fig. 6. LPS and LV earth pits

Case 2: Residential building of 110-meter height

A 110-meter residential building in Mumbai, having 28 stories with four apartments per floor and being occupied by approximately 450 people was also investigated. ELPS has been designed and installed in the building for LPL four in accordance with IS/EC 62305. This installation adheres to Type A earthing, and the earth termination of LPS and the building's LV earthing have been isolated. Meaning equipotential bonding has not been done thus separation distance is not calculable. The LPS earthing has been marked with a green underline in Figure 6, and earth pits can be seen in the figure also.

- Level of protection: 4 ($K_i = 0.04$)
- Number of down conductors: 8 (Kc = 0.44)
- length of the building: 110 meters

Installation photos

Case 3: Residential building of 40-meter height

A 40-meter residential building in Ahmedabad, occupied by approximately 240 people, was also investigated. This building too, a lightning protection system was designed and installed as per LPL four in accordance with IS/IEC 62305. The separation distance in this installation is 0.704 metres and equipotential bonding has been done on the ground floor. After the test joint, the downconductors are connected to a 50 mm^2 XLPE-insulated copper-stranded conductor that is tested for a 100kV impulse withstand voltage and terminates to a type B earthing. As this is a residential building, this insulated conductor was installed to reduce the touch voltage associated with the lightning current, but the separation distance is ignored.

- Level of protection 4: ($K_i = 0.04$)
- Number of down conductors: 5 ($K_c = 0.44$)
- Length of the building: 40 meters

Fig. 7. Downconductors view from the ground floor.

Fig. 8. Insulated conductor from the test joints

Fig. 9. Downconductor view from the ground floor

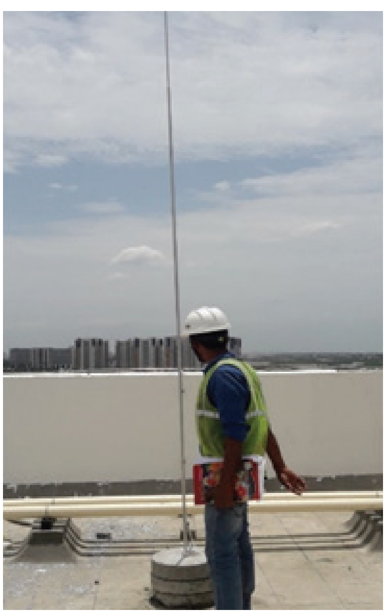

Fig. 10. Air terminal near the metallic water pipe

Fig. 11. Aluminium conductor near the glass façade

Case 4: Commercial building of 90-meter height

A 90-meter commercial building in Bangalore was also investigated. ELPS was designed for LPL 2 per IS/IEC 62305. The separation distance at the top is 2.376 metres and equipotential bonding has been done only on the ground floor. In the air termination section, the aluminium conductor of LPS is routed close to the glass façade and metallic water pipe but is not bonded together and in the down conductor section, the separation distance is ignored. This may result in arcing. Type B earthing is followed in this LPS.

- Level of protection: ($K_i = 0.06$)
- Number of down conductors: ($K_c = 0.44$)
- Insulation material: Air ($K_m = 1$)
- Length of the building: 90 meters

Case 5: Downconductors system using reinforced steel as natural component (with additional continuity conductor)

A 75-meter office complex in Mumbai, having 25 floors was also investigated. The lightning protection system was designed for LPL 3 as per IS/IEC 62305. In this installation, it has been noted that an additional conductor superimposed along the rebars servers as a down conductor. Provision for Equipotential Bonding with RCC column has been provided at rooftops and at various floors. A type B foundation mesh earthing has been used. The separation distance can be ignored due to the continuously interconnected concrete framework used as a down conductor [2].

Installation at the site:

Fig. 12. Downconductors through RCC column

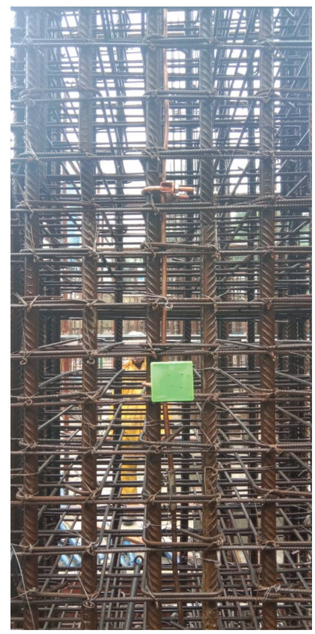

Fig. 13. Provision for Equipotential Bonding with RCC column before concreating

Conclusions

The following are concluded from the above cases:

- In case 1, as this building was constructed in 2010, the LPS is not following any code of practice. The down conductor has been routed through electrical shafts and equipotential bonding has also not been carried out.
- In case 2, the building was completed prior to the publication of the National Building Code of India 2016; consequently, separation distance and equipotential bonding were not practised.
- In case 3, separation distance is not maintained, however insulated down-conductor after test joints, equipotential bonding with the power line and ring earth will increase the safety of people in the event of a lightning strike.
- In case 4, the down conductor is routed near the glass façade and water pipe meaning separation distance is not maintained.
- In case 5, RCC columns have been used as a down conductor with a superimposed continuity conductor. In this installation separation distance need not be considered also and equipotential bonding has been done on every floor.

Building 1 and 2 have been constructed before the publication of NBC 2016.

Building 3, 4 and 5 are constructed after the publication of the National Building Code of India 2016, so equipotential bonding at the ground floor between the down conductor and MET is carried out.

The proper ELPS installation as per IS/IEC 62305 is only followed after the publication of the National Building Code of India 2016. And since the use of natural components for downconductor has been recommended in NBC 2016, an efficient ELPS has become popular. In 2023 almost all high-rise building has been using natural components for down conductor and earthing.

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