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Risk Analysis of Lightning Protection System for Buildings

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Abstract: ***Lightning strike is a very destructive and unavoidable phenomenon that can cause significant damage to the structures and destroys any object which comes in to its radar. Lightning risk assessment includes the study of actual measures that are the real reasons for the risk caused by the lightning strike. It evaluates the hazard and risks of lightning strikes to people, structure and systems. Risk assessment determines the need of lightning protection system and mitigation measures. Risk Assessment for lightning protection system is done by using EN 62305-2 standard by considering IEC standards as a reference. The dimensions of the building are put into the risk assessment software to analyse level of protection. The purpose of this is study is to consider a building and to do a proper risk assessment through software and to propose a lightning protection system for overall protection of the building. Internal protection of the electronic equipment from indirect effects of lightning strikes by using Surge protection devices (SPDs) is also crucial as it helps to protect the electronic devices from damaging effects of indirect lightning strikes.***

Keywords: EN 62305, risk assessment, lightning strike, surge protection, SPDs.

I. INTRODUCTION

Lightning strike is powerful visible electrical discharge in the atmosphere that occurs due to the random movement of clouds. Clouds are naturally charged elements and positive charge resides on the upper portion and negative charge resides on the lower side of the cloud. Initially, air acts as an insulator between these positive and negative charges. When these clouds move randomly due to the stormy weather, a charge disturbance inside the cloud takes place and it becomes difficult for the air to withstand the force, a rapid discharge of electricity is seen which is called lightning strike. The lightning strike occurs either between cloud to cloud or between cloud to earth. Cloud to cloud lightning strikes is not of much concern because they do not have any adverse effect on mankind, but cloud to earth lightning strikes is of much importance as they affect the mankind directly and cause a serious damage physically and economically. The lightning when falls on buildings yields some of following damaging effects:

1) Electric effects: It can damage all the electronics destroying the electrical network. It can also damage the surges by raising the ground voltage.
2) Fire danger: Lightning can ignite the wood wherever it is available in the building and that may result in the fire.
3) Effects on living beings: The smoke produced by the fire may lead to a number of respiratory problems that may cause deaths and the electric shocks thus produced may cause cardiac arrest in different human beings who have contact with the electronic wires.
4) Power surge damage: When the lightning strikes the electrical wiring, it causes an explosion that may also damage appliances other than the electronics.
5) Induction effects: Currents are induced in each conductor. And it may cause a severe damage if these conductors are connected to other electronic equipment like computers.
6) Shock wave damage: The thunder that we hear during the lightning is caused by the shock waves. These waves can be destructive when they are at a closer range. The chimneys made up of bricks and stones are largely affected by this.
7) Luminous effects: An image is formed by the lightning strike on the viewer's retina that makes him remain confused before he regains his sight.
8) Effects due to arching: Proper earthing of the ground electrodes is not done due to the resistive nature of the soil. This may lead to the damage caused by the lightning strike as the current is not properly conducted.

The surge protection devices are an important part of lightning protection system. The surge protective devices are used in the electronic panels to protect the electrical devices from the high voltage current produced by the lightning strikes. This protects the electrical appliances from being explode and prevents the catching of fire. It is concluded that the surge protective devices are an important part of the lightning protection system.

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II. STANDARDS

Following standards are widely followed for risk assessment technique and designing lightning protection (Winter, 2012).

1) Spanish Standard (UNE 21-186: 1996
2) French Standard (NFC 17102)
3) British Standard (BS 6651:1999)
4) American Standard (NFPA 780: 1997)
5) IEC Standard (IEC 62305)

III.RISK ASSESSMENT

A Risk assessment is done in order to identify the required measures to control the risk at workplace or in any building. It helps to decide whether we have covered all what we need or not. It is a process that includes:

1) The identification of the 'risk factors' that may cause hazards
2) To analyse the risk that may be the cause for the hazard
3) To evaluate the risk
4) To determine the better ways to control the risk and completely eliminate the hazard (Horrocks, 2010)

A. Lightning Risk evaluation according to standard IEC EN 62305

It actually includes the study of actual measures that are the real reasons for the risk caused by the 'lightning strike'. Risk Assessment for lightning protection system is done by using IEC EN 62305 standards. These standards provide a base line for designing a proper lightning protection system by inputting the information about the structure to be protected.

TABLE 1
TOLERABLE RISK VALUES AND FORMULAS

Risk	Description	Tolerable values	Formula
R1	Risk of loss of human life	0.00001	RA + RB + RC + RM + RU + RV + RW + RZ
R2	Risk of loss of service to the public	0.001	RB + RC + RM + RV + RW + RZ
R3	Risk of loss of cultural heritage	00001	RB+RV
R4	Risk of loss of economic value	0001	RB + RC + RM + RU + RV + RW + RZ

Whereas,
RA – component related to injury to living beings caused by touch and step voltages;
RB – component related to physical damage caused by sparking inside the structure;
RC – component related to failure of internal systems caused by lightning strike;
RM – component related to failure of internal systems caused by lightning strike;
RU – component related to injury to living beings caused by lightning flash to a service connected directly to it;
RV – component related to physical damage (fire or blast triggered by sparking) due to lightning current transmitted through;
RW – component related to failure of internal systems caused by overvoltage induced on incoming lines and transmitted to the sensitive equipment.
RZ – component related to failure of internal systems caused by overvoltage induced on incoming lines and transmitted to the structure due to the lightning strike that flashes near a service connected to a structure.

Standards recognized the occurrence of damage in four different ways

- Flashes to the structure (S1)
- Flashes near the structure (S2)
- Flashes to a service (S3)
- Flashes near the services (S4)

As a consequence of lightning flashes, below damages are expected

- Injury to living things(D1).
- Physical damage(D2).
- Failure of electrical and electronics system(D3).

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A. Types of Loss

Losses which are mentioned below are specifically considered for evaluating risk calculations.

1) Loss of Human Life(L1)

- Due to fire: Very high. Always occupied.
- Due to overvoltage: High. Vital electrical equipment.

2) Special hazards to life (L2)

- Due to risk of panic: Medium (between 100 and 1000 persons).
- Due to consequences outside the structure: No consequences.
- Loss of Essential Public Services: High. Loss of services.
- Loss of Cultural Heritage: Not relevant.

3) Economic Loss(L4)

- Due to fire: Very high value.
- Due to overvoltage: Very high value.
- Special hazards to economics: No consequences

B. Damage and Loss Relation

TABLE 2
DAMAGE AND LOSS PARAMETERS AS PER IEC/EN 62305

Point of Lightning Strike	Source of Damage	Type of Damage	Type of Loss
Directly to Structure	S1	D1 D2 D3	L1, L4 L1, L2, L3, L4 L1*, L2, L4
Near to the structure	S2	D3	L1*, L2, L4
Lines connected to structure	S3	D1 D2 D3	L1, L4 L1, L2, L3, L4 L1*, L2, L4
Near to the Line	S4	D3	L1*, L2, L4

C. Lightning Risk Assessment of Concrete Structure

Practical example of a building with below dimensions is considered for the risk assessment

1) Length of the structure: 98m.
2) Width of the structure: 22m.
3) Height of the structure: 10m.
4) Total Area Occupied: 12,183.43m².
5) Material of the covering: Concrete.
6) Material of the structure: Concrete.
7) Risk of fire and physical damages: Average.
8) Internal wiring type: Unscreened.

In order to perform the proper risk assessment, data regarding the location is been added in the software to get the real time risk assessment. Data regarding structural and building dimensions, environmental influences, service lines and other major details have been input in the software for Risk calculation.

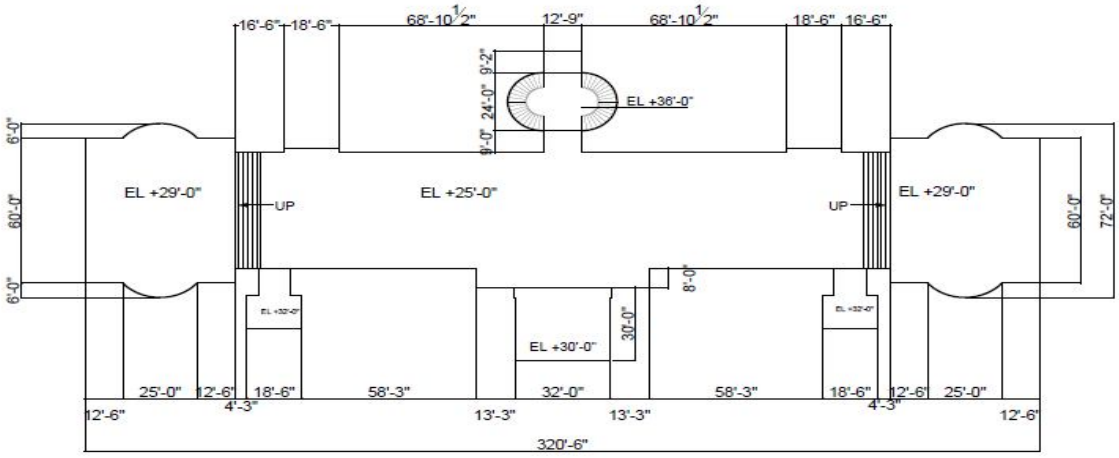


Fig. 1 Structure Dimensions

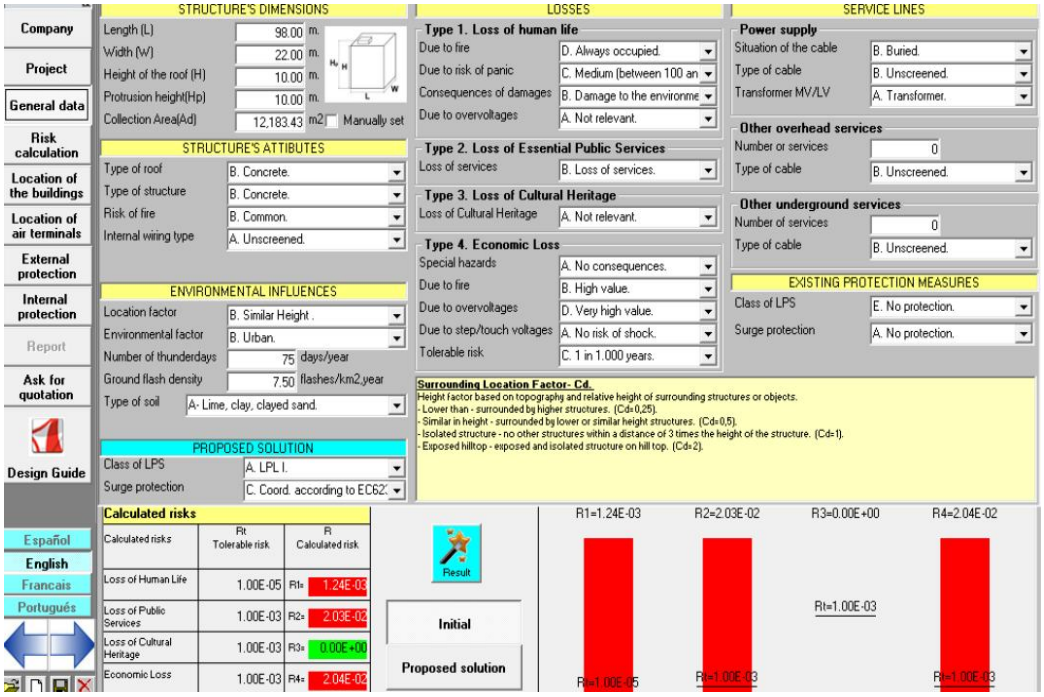


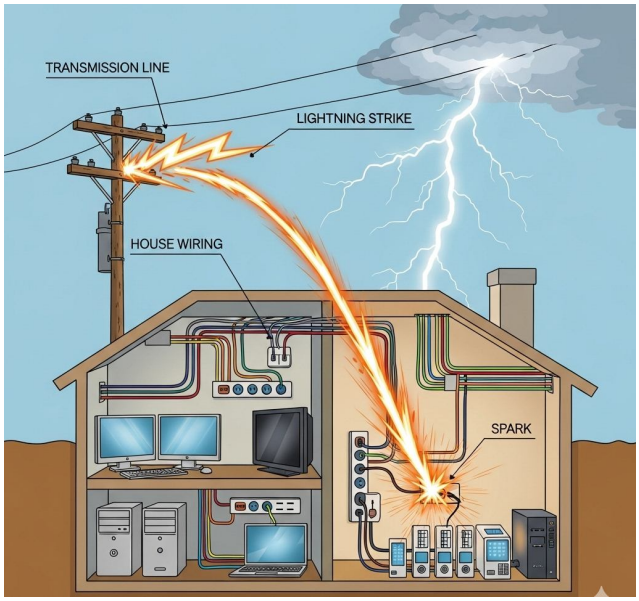
Fig. 2 Risk Calculation

After the entry of relevant data into the software, it is found that Risk Values of R1, R2 and R4 are above the threshold value mentioned in table 1. Based on the results obtained from software, it is evident that lightning protection system of level 1 design is required to protect the building from damaging effects of lightning strike.

IV. INDIRECT LIGHTNING STRIKE

Indirect lightning strikes are also dangerous as when they struck on nearby transmission line, induced voltages in the wiring of household equipment rise and thereby electronic cards of the equipment are burnt. Most commonly observed losses are as under:

1) Damage to power supplies and circuit boards
2) Data loss in IT systems
3) Malfunction of industrial control systems
4) Failure of communication equipment

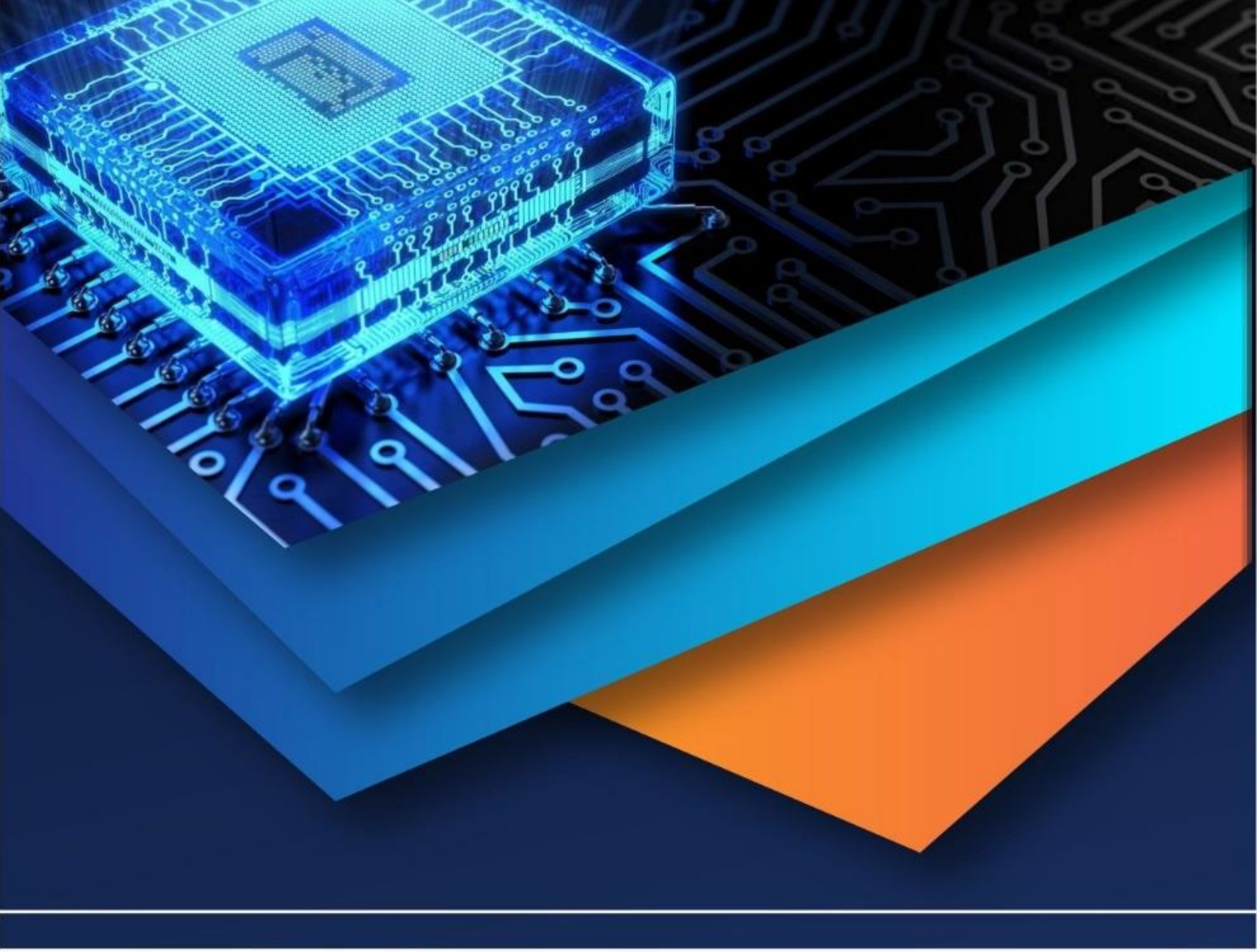


V. CONCLUSIONS

The study demonstrates that a properly executed risk assessment is essential in determining whether a Lightning Protection System (LPS) is required and in defining the appropriate protection level. The proposed external lightning protection measures such as air termination systems, down conductors, and earthing arrangements help mitigate the direct effects of lightning strikes on the structure. Equally important is the implementation of internal protection measures through the installation of Surge Protection Devices (SPDs), which significantly reduce the impact of transient over voltages caused by indirect lightning effects.

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