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Impact of Lightning on Building and Remedial Measures

Rajan N. V.[1]

1(Lecturer in Civil Engineering, Government Polytechnic College,
Kozhikode, Kerala.)

Abstract:

A lightning strike can cause extensive structural damage to a structure. It can cause damage to machinery and equipment both within and outside the structure, as well as endanger individuals. This paper provides a review of lightning protection principles as well as a methodology for providing a comprehensive solution to both the direct and indirect impacts of a lightning strike. Lightning Protection and Grounding of Electrical and Mechanical Equipment for Human Protection, Building Structure and Equipment Protection, Worker Safety at Industry as per my latest practical knowledge in the site environment in extreme climatic conditions of low lying areas of the Gulf Region in challenging projects. This paper discusses all conductor calculations as well as system information indicating the level of protection required for the site. Surge protection for lightning, electrical, and mechanical equipment is one of the most challenging protections in the world because it is unpredictable. As both can cause significant casualties and damage to the buildings and equipment in the road way's surrounds. We shall explore the Impact of Lightning on Buildings and Remedial Measures in this article.

Keywords — **Lightning, Building, Remedial Measures, Structural damage, Equipment's, Electrostatic charges, Building Protection, Lightning stroke.**

INTRODUCTION:

Lightning is one of those natural events that captures people's attention because of its evident ferocity and destructive force. Thunder and lightning were thought to reflect the gods' fury. We are both fascinated and terrified by lightning. The significant harm it causes to property and its unfortunate victims proves indisputably that the imagination is founded on a very real occurrence that can be adequately explained but cannot be combated. Only minimal attempts can be made to manage its effects and consequences. Lightning is a potentially lethal electrical discharge caused by the dielectric breakdown of air between clouds or between clouds and the earth. Certain clouds (cumulo nimbus) produce atmospheric conditions that allow electrostatic charges to accumulate. The breakdown phenomenology, as perceived as a lightning flash, is highly sophisticated (precursor, leader stroke, return discharge, and so on). It is accompanied by thunder, which is caused by the electric arc's rapid expansion of the warmed air.

Lightning mostly strikes natural components (trees, hills, water, and so on), but it can also strike structures, buildings, pylons, and other man-made objects. A differentiation resulting in the separation of two distinct types of effect: "Direct" damage is caused by the circulation of a large current (tens of thousands of amperes) that warms materials and causes severe damage (calcinations, fire, dislocation, or even collapse). - Overvoltage's are caused by "indirect" actions like as conduction, induction, or increasing the earth potential.

Mechanism of Lightning:

Lightning mechanisms are fairly complex, but in a nutshell, they require a very high energy electrical discharge caused by a potential difference between clouds or clouds and the earth.

In 80% of cases, lightning currents exceed 20 kA and can exceed 200 kA (or even more) with escalating durations of a few microseconds. Ground lightning strikes can be classified into numerous types: Ground lightning strikes are classified into four varieties based on the direction in which the charge develops (cloud-to-ground or ground-to-cloud) and whether the charge is negative or positive. Negative cloud-to-ground; Positive ground-to-cloud; Positive ground-to-cloud; Negative ground-to-cloud; and Negative ground-to-cloud. [1]

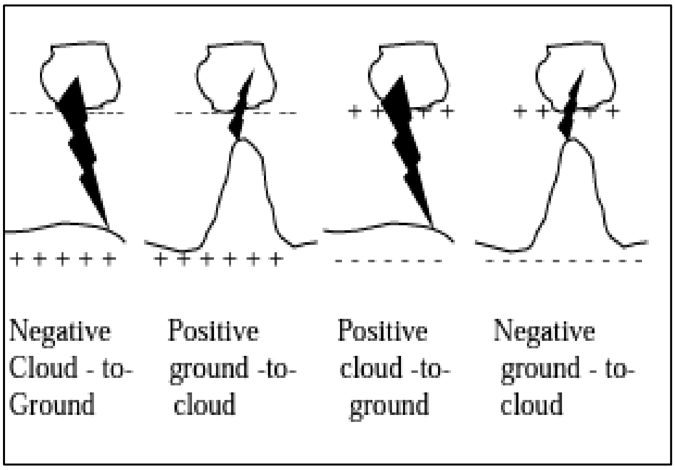

Figure 1: Different types of ground lightning strike

Effects of Lightning:

The effects of lightning are commonly divided into direct and indirect effects.

A) Direct effects (strikes on structures):

A direct strike to a building or structure will seek a path to ground through the structure's lightning protection system or any other metallic path through a series of flashovers that can be exceedingly unexpected. In addition to residences and structures, lightning can strike power lines, antennae, antenna feeders, and overhead telephone cables, as well as mechanical services such as water and gas piping. Direct lightning strikes may be connected. The goal must then be to intercept and reroute these impulses as they enter the building.

B) **Indirect effects (network overvoltage)**:

Secondary impacts, in addition to direct lightning strikes, can be hazardous. Transient overvoltages may occur if lightning strikes a building or any of the above-mentioned services, for example, due to resistive, inductive, and capacitive coupling.

Prior to the 1940s, natural light was the primary source of illumination in buildings, with artificial lights augmenting natural light. In under 20 years, electric Lightning had transformed the workplace by meeting the majority or all of the Lightning needs of the occupants.

DayLightning has lately been an acknowledged component of architectural illumination design due to energy and environmental concerns. The mechanics of dayLightning have remained constant since its origin, but architectural design to support it has evolved.

DayLightning is widely used in buildings to make an architectural statement as well as to save energy. However, the advantages of dayLightning go beyond design and energy. Natural light's psychological and physiological effects should also be considered.

Building occupants benefit from the comfortable space and connection to the environment just as much as building owners and managers benefit from the energy savings.

2 This document summarises the advantages of various wavelengths of light on building occupants. DayLightning has been linked to higher productivity, lower absenteeism, fewer product faults or flaws, good attitudes, less fatigue, and less eyestrain. [2]

Review of Literature:

According to Heerwagen (1986), West conducted a research in 1986 to analyse the impact of light on health by evaluating jail inmates with different window views.

According to his research, inmates with windows viewing a meadow or mountains had significantly lower rates of stress-related sick calls than inmates with views of the prison courtyard and buildings.

In addition, second-floor inmates reported less stress-related sick calls than first-floor inmates. One of the reasons for the disparities in sick calls was a more panoramic view from the second level, which offered higher favourable psychological benefits. Inmates on the first floor endured additional stress owing to a lack of privacy due to their visibility to visitors. [3]

According to 3M Austin Centre employee Nick Lampe (2001), "the atrium creates a more welcoming, relaxed, and comforting environment because artificial lights are not clicking overhead." He spent half of his day in an office one workstation away from a window, and the other half in an office with windows on two walls that opened to the atrium. Lampe (2001) stated that at an office with more window space, he "does not feel as drowsy and is more 15alert."

He did notice, however, that direct sunlight entered the windowed office space for portion of the morning, causing his eyes to adjust to the intense light. Lampe preferred working in an office with more windows for natural light, despite the direct glare. The fact that the 3M Austin Centre was built more recently than his previous jobs influenced his opinion of the facility. Lampe (2001) discovered that natural light is the most effective factor in boosting his attitude towards his working environment. Taking breaks in the daylit atrium, he said, was "refreshing." Lampe (2001) prefers the center's more natural setting because "it is motivating, calming, and puts me in a better mood."[4]

OBJECTIVES:

- Determine the location of all sensitive loads in the structure.
- Determine the location of the electrical and electronic systems, as well as their entrance points into the structure.
- Determine whether a lightning protection system is installed on or near the building.
- Research the regulations that apply to the site of the building.

RESEARCH METHODOLOGY:

The purpose of this research study is to suggest possible remedial measures to reduce the impact of construction and maintenance activities on the communities living around an ongoing construction project so the factors will be taken from the literature and a questionnaire will be developed to collect the data from construction industry experts and the collected data will be analyzed.

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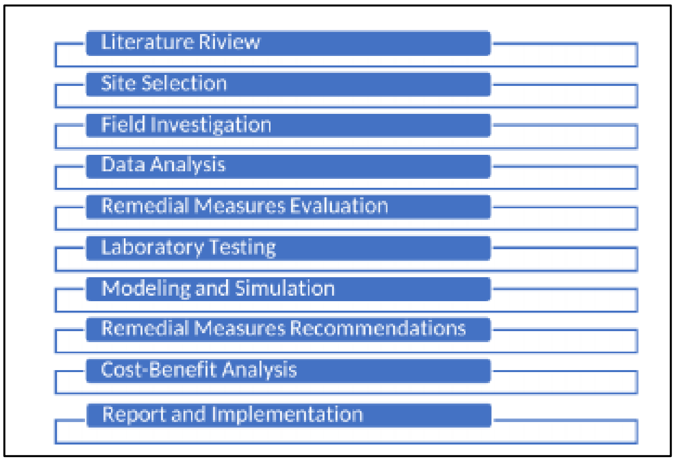


Figure 2: Framework for analysing structural flaws

RESULT AND DISCUSSION:

Building Protection System:

The building protection system's job is to defend it from direct lightning strikes. The system is made up of the following components:

- the lightning protection system's capture device;
- down-conductors designed to carry the lightning current to earth; and
- "crow's foot" earth leads joined together.

Equipotential bonding connects all metallic frames to the earth leads. When a lightning current travels through a conductor and there are potential differences between it and surrounding earth-connected frames, the latter can cause destructive flashovers. [6-7]

External Protection for Building Lightning:

A. These lightning conductors serve as a protection system for buildings against direct lightning strikes. They prevent damage related to the lightning strike itself and circulation of the associated current by catching the lightning and running the discharge current to earth. There are four groups of lightning conductors: [8-10]
   1. Franklin rods are metal rods that have been installed over a structure at strategic locations for lightning strikes. These terminals are linked to a system of conductors that run horizontally and vertically and terminate at earthing terminals. The protected structure in a Faraday Cage is covered by a network of rods, conductors, and earth terminals. Franklin Rods come in a variety of sizes and shapes to suit applications, and we have the capacity to design and produce a unique system to meet your requirements.
   2. Lightning conductors that have a spark over a device are an improvement over single rods. They have a spark over device that generates an electric field at the tip of the spear, aiding in lightning capture and enhancing their efficiency. On the same structure, various lightning conductors may be installed. They as well as their earthing electrodes must be connected.
   3. Lightning conductors with mesh cage: To provide this protection, many down conductors or tapes are laid out symmetrically all around the structure. For extremely exposed buildings housing extremely sensitive installations, such as computer rooms, this type of lightning protection system is used.
   4. Lightning conductors with earthing wires: This system is used above some buildings, outdoor storage areas, electric lines, etc. These are covered by the sphere's electrogeometric model.

B. Electrogeometric model: This method has been used to design shielding systems and to provide a solid scientific foundation for estimating the annual number of lightning strikes to buildings and electric power components. This model, also known as an imaginary sphere, specifies the spherical volume that, in theory, a lightning conductor would protect based on the strength of the first arc's discharge current.

C. Capture surface areas: When a site needs to be protected has multiple buildings or is larger than the reach of a single capture device (lightning conductor), a protection strategy needs to be developed. When a site is comprised of buildings of varying heights, it is never easy to completely cover it. It is possible to see areas that are not covered by the protection plan by superimposing it over the area's layout.

D. Down conductors: As far as practical limitations allow, down conductors should travel the shortest distance between the earth termination system and the air termination system. The lightning current distributed among down conductors is better the more there are of them. Equipotential bonding to the structure's conductive components improves this even more. Around the outside of the structure, there should always be a minimum of two down conductors. To carry the majority of the lightning current, down conductors should, whenever possible, be installed at each exposed corner of the structure.

External Protection for Building Lightning: [11-13]

A. Fuses and circuit breakers are the most frequently used protection devices. They provide both active and passive protection for the installation. These technologies are too slow in comparison to the lightning phenomenon and won't shield electrical and electronic equipment from lightning-induced overvoltages. Voltage surge protectors offer the installation active security. Only when they are installed carefully can these voltage surge protectors be used to their fullest potential. Therefore, it is crucial to take into account factors like model selection, positioning, connection, etc. Along with this requirement, the installation's physical characteristics (such as scale, equipotentiality, an earthing system, circuit separation, etc.) must also be met. Passive protection refers to all of them collectively.
B. Lightning strike resistance of equipment: Lightning strikes have a high energy output. Regardless of this, the strike results in overvoltages and current values that depend on the installation's structure and the location of the energy production. Based on a comparison between the impulse voltage withstands value (overvoltage category) of the equipment and the prospective value of the lightning strike according to installation conditions, it is necessary to protect equipment against overvoltages.

The Simple Lightning Rod:

The lightning rod is a metallic capturing point installed at the roof of the structure. It is grounded by one or more conductors (often copper strips). [14]

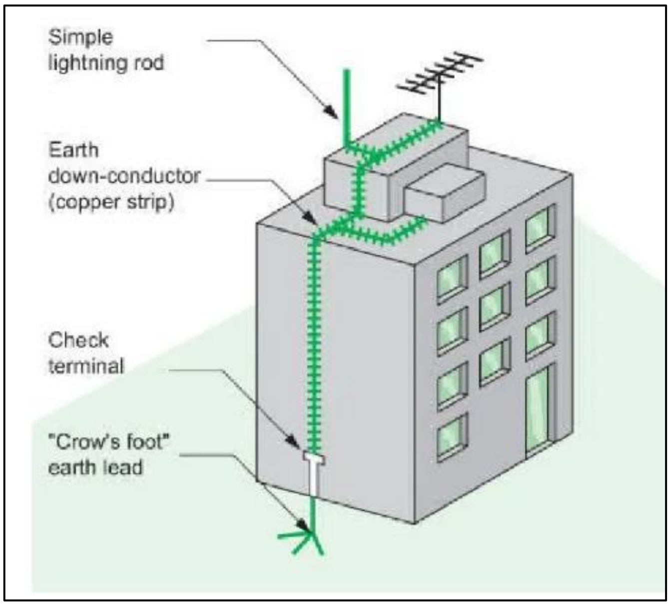
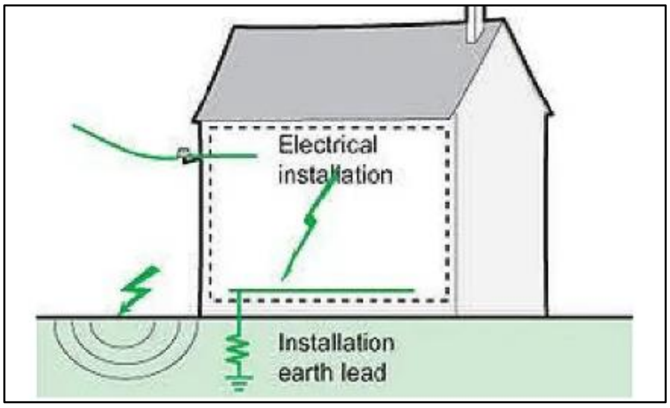


Figure 3: Lightning Falls Near a Building



The lightning strike creates the same types of overvoltage as previously stated. Furthermore, lightning current travels from the earth to the electrical installation, resulting in device failure. [15]

CONCLUSION:

Lightning is an important part of the Earth's environment, although it may be dangerous at times. It can be difficult to understand why certain regions appear to be lightning prone. Very tall things are usually targeted because they represent the shortest path from a cloud to Earth. When lightning cannot find a quick and easy path, it usually causes injury, damage, and fires. A good lightning protection system aids in providing that path, minimising the chance of human or animal injury. The research underlines the importance of developing a lightning-safe culture. It examines the problems, Indian standards, and lightning protection methods, as well as current awareness initiatives and R&D needs for lightning safety in the Indian context.

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