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Impact of Lighting on Structures & Remedial Measures

Himanshu Nawkhare[1] , Anjali Ukey [1], Akshay Bhagwat [1], Nikhil Kuthe [1], Prof. Pranjali Karhade [2]

[1] UG Student , Civil Engineering Department, Swaminarayan Siddhanta Institute of Technology, Nagpur, Maharashtra, India

[2] Assistant Professor, Civil Engineering Department, Swaminarayan Siddhanta Institute of Technology, Nagpur, Maharashtra, India

ABSTRACT-Lightning is a natural phenomenon which develops when the upper atmosphere becomes unstable due to the convergence of a solar heated, vertical air column on the cooler upper air mass. These rising air currents carry water vapour which, on meeting the cooler air, usually condense, giving rise to convective storm activity. To be capable of generating lightning, the clouds needs to be 3 to 4 km deep. The taller the cloud, the more frequent the lightning. The centre column of the cumulonimbus can have updrafts exceeding 120 km/hr, creating intense turbulence with violent wind shears and consequential danger to aircraft. This same updraft gives rise to an electric charge separation which ultimately leads to the lightning flash. The motivation behind this topic is to protect our structures & reduces damage of structure due to lightning. Lightning is a deadly but often avoidable hazard. If the proper precautions are taken the threat of this hazard can be greatly reduced. Through education people can raise their awareness and understanding of lightning strikes, therefore reducing their risk of injury or death.

KEYWORDS: Lighting, Structures, Hazard, Flash, Building, Construction

I. INTRODUCTION

Rapid urbanization in India, is pushing the energy demand at an unpreceded rate of 8% per annum. The sprawling of compact multi-storied high rise buildings, currently an archetype to meet urbanization demands, is increasingly putting pressure on urban energy needs. Moreover, non-stringent building bye-laws and lack of solar legislation add to the burden. While such development is better from the point of minimizing energy usage for transportation, the close proximity of the high-rises limits the skycomponent and daylight penetration. This in turn affects the quality and the quantity of daylight received, especially at the lower floors, and puts pressure on artificial lighting needs. Especially, in a country like India which has prolonged sunlight hours it seems imperative to have regulatory norms that integrate daylighting into the housing sector. The building bye-laws of Indian cities prescribe that every habitable room should have one or more apertures like windows, opening to external environment such that in no case the glazing to floor ratio be less than 10% of all habitable spaces and the prescribed minimum distance between buildings is based on the "sustained vertical angle requirements" as per NBC-2005 Part 8 Sec 1. These laws were first developed in the UK, primarily for low rise terraced houses, which assume that all windows receive a fairly good amount of "sky component" and that there is a constant angle of obstruction among the buildings. Given that Indian cities are growing taller and the windows have varying skyline obstruction, these laws become less effective. The building design itself suffers with no guarantee on daylight availability and performance. This situation calls for remedial measures in building bye laws that can meet with the contemporary demands in the growing residential sector. One of the critical characteristic of India is its low socio-economic class driven urbanization. This has led to a huge deficit of affordable housing in India. As a remedial measure, the Government of India has formulated the scheme of "Housing for All- 2022", which aims to build 20 million affordable houses in the next seven years. Under this pretext it would be judicious to propose daylight inclusive building bye-laws for this upcoming housing stock. Hence, this study intends to propose a route towards daylight inclusive building bye-law and policy formulation. First, the study describes the gaps in current bye-laws and then estimates the daylight performance of an existing building. It then suggests the metric of Usable Daylight Illuminance (UDI) for evaluating the energy saving capability of residential buildings. Finally, an energy management matrix is designed as a method for formulating daylight inclusive building bye-laws.

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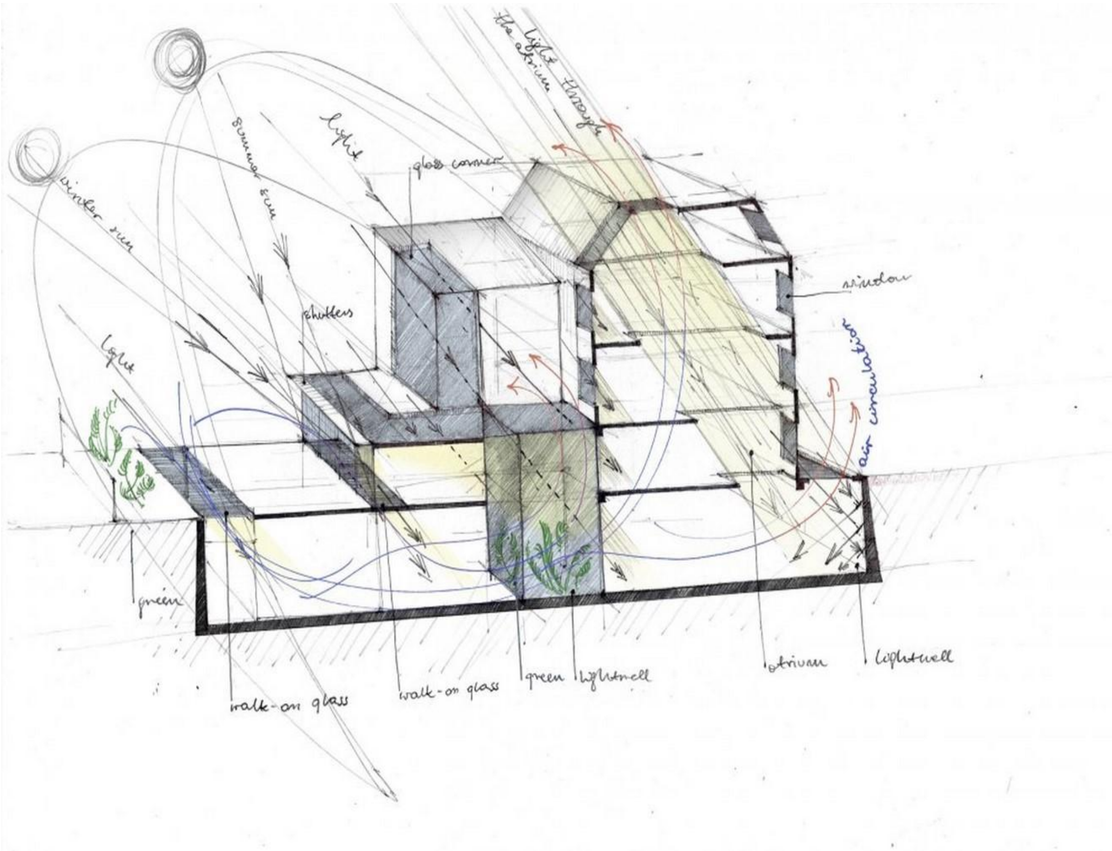
The phrase "**when lightning strikes**" is frequently used as a euphemism for an uncommon occurrence when lightning strikes. Every year, institutes such as IMD publish the Monsoon date. Lightning strikes are common during monsoon rain; however, the most dangerous lightning strikes occur during pre-monsoon or untimely rain. Lightning, as the name implies, is a dazzling flash of light created by electrical discharges that occur all over the world, whether in urban areas, rural areas or even in open fields. In theory, lightning is caused by a charge imbalance between thunderclouds and the ground or the clouds themselves.

The majority of lightning strikes occur between clouds, with the rare exception of lightning striking the earth. In the blink of an eye, a lightning strike might deliver thousands of mega-amperes of current. Lightning is most likely to strike the closest point on Earth to it, which has a large potential for positive charges. In other words, a towering building, structure, electrical tower, or even trees that may discharge electricity to the ground are considered the closest point.

Lightning is a massive electrical discharge that originates in clouds or the atmosphere. In-cloud lightning, which accounts for the bulk of lightning incidents, occurs wholly within a cloud or clouds or between a cloud and the air, according to the National Severe Storms Laboratory. When negative electricity from the atmosphere combines with the positive charge of an object below, deadly cloud-to-ground lightning strikes occur.When the electrical charge in the atmosphere is less than a hundred yards from the ground, objects like trees and buildings emit sparks to meet it. When those sparks meet, the resulting channel causes a massive electric current surge that goes rapidly downhill, culminating in the flashing bolt we know as lightning.

Lightning travels at the speed of light, or 186,000 miles per second, according to NASA. Lightning can strike anywhere outside, but it is most likely to do so near water or towering, isolated objects like trees. It's important to keep in mind, however, that the tallest object isn't always the target.



[Fig.1.1: Natural Light on structures]

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II. LITERATURE REVIEW

[1] A Study On-Analysis and Estimation of Illumination Levels in Construction Sites (2022)

Lighting or illumination is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight. Day lighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants. Indoor lighting is usually accomplished using light fixtures and is a key part of interior design. Lighting can also be an intrinsic component of landscape projects. The construction industry has the largest number of injuries compared to other industries. Many projects are often hampered by underperformance. This seems to indicate the lack of illumination level management in the way we manage projects. Thus, reducing accidents and determining construction lights are extremely important. On the other hand, it is impossible to have any projects without lighting system. Thus, it is essential to have effective illumination performed in the construction projects. Illumination plays a vital role in indoor and outdoor activities, and it is very necessary and essential factor to do work more accurately and work to do as per design within planned time and cost. Poor illumination could bring problem to worker as well as organization. By doing analysis and estimation, whether illumination is sufficient without any strain to worker thus creates risk free working environment and no strain to the worker who is involved in night with suitable amount of illumination at same time with proper height and distance. The analysis was conducted in a under construction site whether illumination levels are as per the requirements and standards and whether there is any lapse there by suggesting them alterations and redesigning the space so that the illumination levels are as per the standards.

[2] A Literature Review of the Effects of Natural Light on Building Occupants (2002)

This paper presents summary information from a noncritical literature review on daylighting in buildings. It is by no means exhaustive, and no attempt has been made to determine the scientific nature of the studies that are cited. It was the goal of this document to compile a listing of the literature that is commonly cited for showing the impacts of daylighting in buildings. NREL does not endorse any of the findings as the citations have not been critically reviewed. Many building owners and architects have reported energy savings received from daylighting. Looking at the energy consumption of commercial buildings in the United States demonstrates the importance of saving energy. According to the Department of Energy's Office of Building Technology, State and Community Programs (BTS) 2000 Databook, commercial buildings consumed 32% of United States electricity in 1998, of which 33% went to lighting. Not only is electrical lighting responsible for a significant amount of the electrical load on a commercial building, but it can also cause excessive cooling loads. Utility costs for a building can be decreased when daylighting is properly designed to replace electrical lighting. Along with the importance of energy, studies have demonstrated the nonenergy related benefits of daylighting. Quantitative studies and qualitative statements are used to summarize the use of daylighting in buildings, its effects on occupants, and its potential economic benefits. Data have been compiled from books, periodicals, Internet articles, and interviews. The books, periodicals and Internet articles provided the background information necessary to identify the main subjects of the paper. Interviews provided details related to specific buildings and companies that have integrated daylighting into their building. Daylighting data have been divided into Wavelengths of Light, The Affects of Light on the Body, and the following building sections: offices, schools, retail, health care, and industrial. The sections Wavelengths of Lights and The Affects of Light on the Body help describe the impact daylight has on building occupants. Each building section includes the effect daylight has on the building occupants psychologically and physiologically. Economic data have been cited in the categories in which information was found.

[3] The effect of lighting environment on task performance in buildings – A review (2020)

The effects of indoor environmental conditions on human health, satisfaction, and performance have been the focus of research for decades. This paper reviews and summarizes the impact of lighting environment on task performance, specifically for the built environment audience. Existing studies included a variety of performance tests on cognitive performance and perception, visual acuity and reaction, memory, reasoning, and labor productivity. Illuminance, luminance ratio and correlated color temperature were found to affect performance in different ways, reflecting the impact of experimental techniques, conditions, performance evaluation methods used and data analysis methods. These were reviewed and categorized, with discussion on limitations related to sample size, modeling approach, carryover effects and other factors affecting individual differences in performance, with recommendations for future improvement. Although no universal conclusions can be made, in general, task performance seems to improve with higher

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illuminances, contrast ratios in the range of 7–11:1 (while always making sure that glare will not occur in the space) and higher correlated color temperature, while spectral tuning in the red or blue wavelengths has also shown positive effects. To obtain more generic evidence, future studies should be more consistent in terms of experimental procedures and overall light conditions, and also consider the effects of vertical illuminance, daylight provision/control, and outside views on task performance. Finally, studying performance with multi-factorial designs in a human-centered optimized manner (such as deploying variable lighting scenarios optimized for various tasks) can lead to deeper understanding of lighting effects on task performance, and ultimately to improved lighting design and operation in buildings overall.

[4] Daylight in Buildings and Visual Comfort Evaluation: The Advantages and Limitations (2021)

Exposure to daylight significantly affects the psychological well-being of occupants by diminishing headaches, eye tensions, or stress. Daylight penetration is a matter of collaboration between building façade and perimeter zones that can be controlled through façade design features. This study reviews available daylighting systems to block or redirect natural light inside the space and their overall performance. Adaptation found to be the main key feature of daylighting systems to improve their effectiveness in indoor environments. As the main implication of such systems on the visual comfort performance of occupants, a list of quantitative indices is studied based on their mathematical equation to outline their advantages and limitations. Findings revealed a lack of agreement on acceptable indoor illuminance thresholds for most of the indices and the absence of a reliable glare index in presence of sun within the view field of the occupant. Similarly, many green building certifications propose a specific criterion to assess view out but remained a challenge for future studies.

[5] According to Kim and Anderson, (2013) There is an urgent need in the architecture, engineering, and construction industries for new programs and methods of producing reliable energy simulations using building information modelling (BIM) technology. Current methods and programs for running energy simulations are not very timely, are difficult to understand, and lack high interoperability between BIM and energy simulation software. It is necessary to improve on these drawbacks as design decisions are often made without the aid of energy modelling leading to the design and construction of no optimized buildings with respect to energy efficiency. The goal of this research project is to develop a new methodology to produce energy estimates from a BIM model expeditiously and to improve interoperability between the simulation engine and BIM software. In the proposed methodology, the extracted information from a BIM model is compiled into an input file and run in a popular energy simulation program on an hourly basis for a desired period. The case applied in this paper showed that the application of this methodology can be used to quickly provide energy simulations from BIM models. With the aid of an easy-to-run and easily understood energy simulation methodology, designers will be able to make more energy conscious decisions during the design phase and as changes in design requirements arise.

[6] According to (Kim and Anderson, 2013) Here it is an essential need in that architecture, engineering & construction activities for new programs & methods of providing reliable energy simulations utilizing building information modelling technology. Modern methods & programs for controlling energy simulations are not really timely, are hard to understand & lack high interoperability among BIM and energy simulation software. It is important to increase on those drawbacks as draft decisions are usually made without that aid of energy modelling starting to the design & construction of non-optimized buildings with regard on energy performance. The aim of this study project is to produce a new methodology to produce energy estimates from a BIM model expeditiously & to increase interoperability among the simulation engine & BIM software. In the suggested methodology, the selected information of a BIM model is arranged into an input data file & run in a modern energy simulation program on an hourly basis during the desired period. The matter applied in the paper showed that this application of that methodology can do used to instantly provide energy simulations of BIM models. By the aid of an easy-to-run & easily recognized energy simulation methodology, architects will be capable to make extra energy conscious judgments during the research phase & as differences in design conditions arise.

[7] According to Kim and Anderson, (2013) It is recognized that there is a need in the architecture, engineering, and construction industry for new programs and methods of producing reliable energy simulations using BIM (Building Information Modelling) technology. Current methods and programs for running energy simulations are not very timely, difficult to understand, and lack high interoperability between the BIM software and energy simulation software. The goal of this research project is to develop a new methodology to produce energy estimates from a BIM model in a more timely fashion and to improve interoperability between the simulation engine and BIM software. In the proposed methodology, the extracted information from a BIM model is compiled into an INP file and run in a popular energy simulation program, DOE-2, on an hourly basis for a desired time period. Case study showed that the application of this

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methodology could be used to expediently provide energy simulations while at the same time reproducing the BIM in a more readably three dimensional modelling program.

[8] According to Ahn et al. (2014) BIM (building information model) enables information sharing and reuse for interoperability between prevalent software tools in the AEC (Architecture, Engineering, and Construction) industry. Although a BIM based energy simulation tool can reduce costs and time required for building energy simulation work, no practical interface between CAD tools and dynamic energy analysis tools has been developed so far. With this in mind, this study suggests two approaches (Full automated interface (FAI) and semi-automated interface (SAI)) enabling information transition from CAD tools (e.g., IFC) to Energy Plus input file, IDF. FAI, if ideally developed, can convert IFC to IDF based on the use of pre-defined defaults without requiring human intervention. In contrast, SAI converts geometry information drawn from IFC to IDF and then require human data entry for uncertain simulation inputs. For this study, a library building was chosen and space boundary generated from ArchiCAD 13 was employed for geometry mapping. The Morris method, one of sensitivity analysis methods, was used for identifying significant inputs. In FAI and SAI, dominant inputs, out of the Morris method, were identified for Monte Carlo simulation to quantify probabilistic simulation outputs. In the paper, FAI and SAI simulation results are cross-compared, and pros and cons of FAI and SAI are discussed.

[9] According to Blora, (2012) Building Information Modelling (BIM) efficiently combines environmental analysis in this design & performance of high-performance structures. Building Energy Modelling (BEM), a subset of BIM, operates various simulation engines for predicting the environmental review of buildings. As the need for high-performance buildings should be increased, BEM has promoted the delivery of buildings that reach expected production requirements. The study objectives were to 1) estimate various BEM tools, and 2) produce guidelines for applying BEM tools in design & delivery of high-performance structures. 12 BEM tools were assessed using our examples: interoperability, user-friendliness, possible inputs & possible outputs. The top three programs (Autodesk Ecotect, Autodesk Green Building Studio and IES) did choose based on the evaluation. Each of those selected BEM tools were applied in this study to simulate energy expenditure, daylighting production, and general natural ventilation to two buildings, 1 LEED certified & 1 non-LEED approved. The results of this study were used to analyse the environmental review of the two structures & to develop guidelines for using BEM devises to analyse structure environmental production.

[10] According to Bardhan and Debnath, (2016) Building sector in India consumes about 33% of total electrical energy use, out of which 25% is accounted by the residential sector. This can be effectively reduced by utilizing daylighting as an essential component of building design strategy. Indian building codes lack specific daylight-inclusive design guidelines, which can provide policy support in reducing the energy consumption. In this study, energy sustainability through daylighting is studied with respect to daylight performance of a middle income, residential apartment in the city of Mumbai. Useful Daylight Illuminance (UDI) is used as the performance metric. The effect of built components like window-to wall ratio (WWR) and orientation on the UDI ranges was studied. Occupancy behaviour was modelled using an UDI threshold of 500 lx, and an energy management matrix (EMM) was derived. It has been found that at south-east orientation and at 20%WWR, the basecase building would save up to 26% lighting energy. Finally, a methodological framework for developing a policy toolbox using EMM was proposed as a route towards designing daylight inclusive building bye-law.

III. PROPOSED METHODOLOGY

3.1 METHODOLOGY

This study aims to update the literature in terms of current advantages and limitations of different daylighting systems and visual comfort quantitative indices. To this end, a critical review and analysis was conducted for this research according to its definition in four main steps:

a) an extensive research through cross-referencing to identify the key papers in the field,
b) evaluating the literature based on their contributions to their respective functions,
c) outlining the key research gaps, and
d) highlighting the potential recommendations for future investigations.

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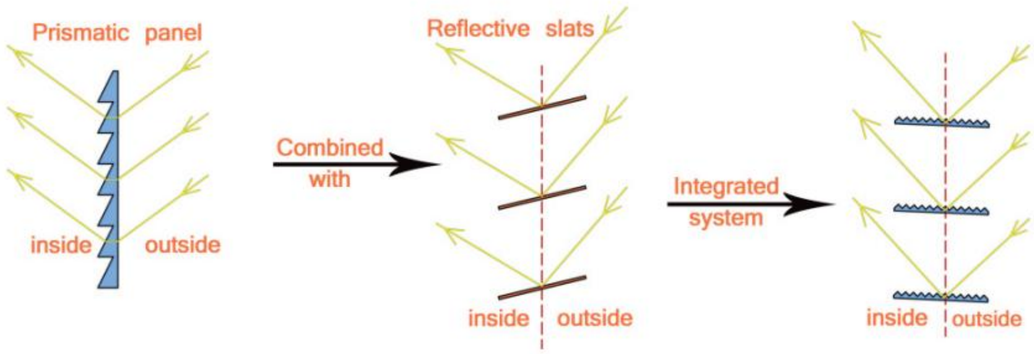
3.1.1 Daylighting systems:

Windows are not only apertures in building envelopes anymore since new innovations like double-skin facades changes the underlying definition. Nonetheless, windows are used to mainly provide views to outdoors and daylighting. To this end, there are two main approaches to deliver more daylight to the interior, by increasing the floor area fraction near to the fenestrations that require architectural design strategies, or applying daylighting optical structures to deliver light thoroughly beyond perimeter zones. In order to redirect light or prevent excessive sunlight penetration, advanced daylighting techniques can be helpful, especially in cases where particular tasks are performed or a high degree of visual control is essential. Substantially, selecting a proper system should take into consideration three main aspects: (1) window or other opening's functionality (e.g. visual connection and/or permit daylighting); (2) the responsibility of the system (e.g. redirecting and/or blocking light); and (3) the interaction of the system with other available systems. As a result, a wide range of daylighting systems have been applied in different researches and experiments that are either played a role as guiding the daylight into the space or as shading systems, in which the following section discusses the features of each system individually.

3.1.2 Prismatic panels

Prismatic panels are planar components including a flat surface and a prismatic patterned side composed of transparent materials such as polymers. These panels are usually consolidated within window panes for low maintenance. The basic function is to redirect diffused lights from the highest point of sky towards the deepest side of the room especially in highly obstructed sites and the second role is to reflect certain light angles while transmitting from other angles. The panels can be applied as a fixed light-guiding system or as an integrated adaptive system. The former type usually used in glazed roofs aimed to redirect the diffuse daylight within certain angles, while reflecting direct sunlight of other directions through a reflective coating (aluminium), and the latter case is normally found as louver form to reflect sunlight from a certain angle by entire inner reflection.



[Fig.4.1: Fixed and adaptive prismatic panels]

However, if they are placed vertically to deliver daylight deeper into the interiors, they can play as an anti-glare system except when sunlight enters directly. In practice, prismatic panels are translucent and falsify the outdoor view and preferably should be positioned vertically higher than eye level to maintain the visual field for users.

The system is able to transmit light by 90%; however, under overcast sky conditions, it decreases daylight factor imperceptibly comparing with clear glazing. Moreover, the overall performance of the system highly depends on the deflecting angles and climate, although under sunny sky conditions has a potential in energy savings. Besides, an integrated system was developed to increase the indoor illuminance levels in University of Berlin, Germany by Hüppe, including a layer of prismatic panel for sun shading and a semi-perforated blinds to deflect the diffuse light; however, as they are placed internally, the shading factor is quite low and the visual connection to outside is extremely reduced.

3.1.3 Laser-cut Panels (LCP)

According to the inventor, LCP can be installed as the main glazing system or as a second internal glazing above eye level to perform the same as light shelf or reflective blinds. Technically, it is produced by implementing parallel laser cuts with acrylic materials to act as small interior mirrors to redirect light in high portion especially in rear areas of the

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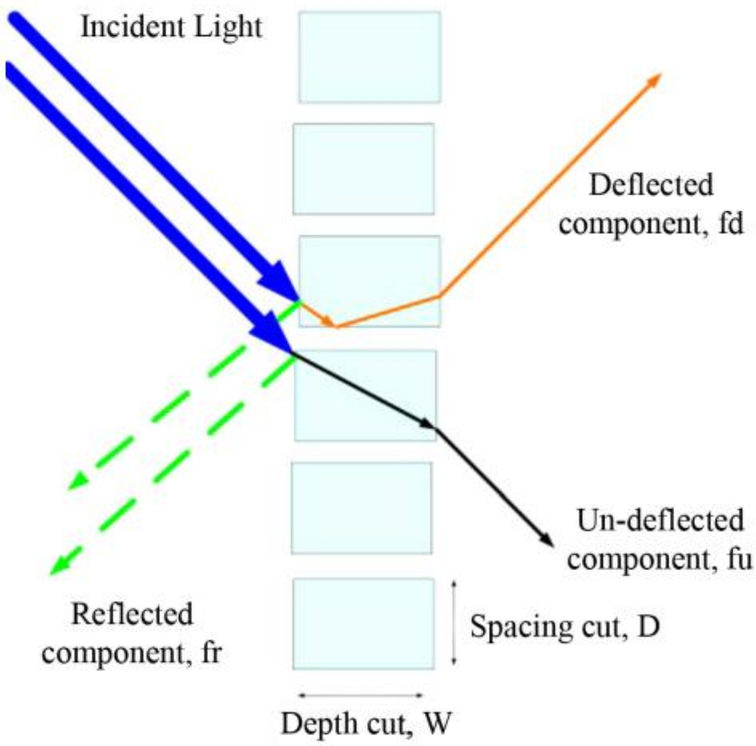
room through passing the voids by ordinal process of refraction and reflection, while preserving a good visual field. With regard to risk of glare, there is an insignificant quantity of light scattered by the LCP due to sharp edges of the system, although glare can still happen through direct sunlight when a substantial portion of light is sent without any deflections. Thus, to reduce discomfort glare, venetian blinds should be placed in front of the LCP.



[Fig.4.2: Light path through LCP system]

3.1.4 Light shelf

Light shelf is designed to shade and redirect daylight through its top surface onto the ceiling and provide a glare-free visual field by dividing a window into a view zone and a clerestory zone above. With regard to its position, external light shelves perform better in terms of blocking direct sunlight and reflecting daylight towards indoor that might cause unbalanced illuminance, while interior ones maximize the sunlight flows into the indoors with high risk of glare. According to a study, a comparison between four scale model of light shelf and conventional overhang is conducted in Madrid, Spain, in which the study showed that light shelf performed more efficient than a classical overhang by 25% increment of redirecting light in terms of illuminance levels and it is revealed that the system reduces the existing illuminance contrast between areas near to window and back of the room by enhancing the distribution levels.

Further optical improvements on light shelves were suggested by: (1) geometrical modification towards a curved and fragmented light shelf for sunlight reflections due to certain solar altitudes passively, and (2) available semi-specular films in market could increase the efficiency. Moreover, the same study tested four light-shelf designs combined with light pipes in Los Angles as depicted. The curved configurations coated by highly reflective films (88% reflectance) aimed to redirect sunlight while the altitude changes, therefore the inclinations were calculated by taking into account the window orientation and latitude, to ensure an optimum design solution for narrow spread and specular reflections. As a result, using curved light shelves can increase indoor illuminance in rear zones up to 10 m away from the window for equinox sun angles and south faced facades (northern hemisphere).

Furthermore, a conceptual tracking light shelf system was proposed that reflects daylight into the space by utilizing both diffuse and direct sunlight called VALRA (Variable Area Light Reflecting Assembly). This system adjusted a reflective

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film made by plastic over a spring-loaded tracking roller, in which its efficiency is limited to maximum 9m distance from window depending on sky changes and boarding limits.

3.1.5 Sun-directing glass

This technology is very effective in direct or diffuse daylight redirection, although the interior luminance intensity must be kept under control to avoid discomfort glare. The main element of the system is a series of curved acrylic strips with high refractive index (comparing with gas) which are placed within a double-paned window as a sealed unit and play as optical light elements by total internal reflection to guide incoming daylight within 15° to 65° onto the ceiling especially at mid-latitudes in sunny skies. In practice, sun-directing system is translucent and reduces visible light penetration in which it should be applied above eye height to avoid glare without distorting view, confirms the possible combination of horizontal and vertical internal reflections of the system which leaded to a relatively glare-free uniform illumination onto the ceiling without any tracking parts except in overcast sky conditions, although according to the possibility of discomfort glare still exists due to the bright illuminance of the system itself.

IV. RESULTS & DISCUSSION

4.1 PROTECTION OF STRUCTURE FROM LIGHTENING

Lightning protection systems, which consist primarily of lightning conductors (structural protection) and voltage surge protectors (overvoltage protection), provide excellent protection when properly defined and implemented.

A. External Protection

a. Protection system (lightning conductor)

These are designed to shield structures from direct lightning strikes. They avoid harm from the lightning strike and the related current circulation by capturing the lightning and running the discharge current to earth.

There are four different types of lightning conductors:

i. Single rod lightning conductor (franklin rods): Depending on the size of the structure and the down conductors, these can have one or multiple tips. They are either directly connected to the installation's earthing electrode (foundation) or, depending on the type of protection and national work norms, to a specific earthing electrode (lightning conductor earthing electrode) that is connected to the installation's earth.

ii. Lightning conductors with spark over the device: The single rod has evolved into these. They have a sparkover device on the tip that creates an electromagnetic field, which helps them capture lightning and improves their effectiveness. On the same structure, many lightning conductors might be put. They, as well as their earthing electrodes, must be linked.

iii. Lightning conductors with meshed cage: The meshed cage is made out of a network of conductors that wrap around the outside of the building, enclosing its entire volume. At regular intervals on projecting locations, catcher rods (0.3 to 0.5 m high) are inserted into this network (rooftops, Cast iron guttering, etc.). Down conductors connect all of the conductors to the earthing system (foundation).

iv. Lightning conductors with earthing wires: Above some buildings, outdoor storage areas, electric lines (overhead earth wire), and other structures, this system is used. These are covered by the sphere's electrical geometric model.

b. Electro geometric model

The selection and placement of lightning capture devices necessitate a thorough examination of each site, with the goal of ensuring that the lighting "falls" at one of the predetermined spots (lightning conductors) rather than elsewhere on the structure. Depending on the sort of capture device, there are several ways to accomplish this (lightning conductor). The "electro geometric model" (or imaginary sphere model) method, for example, determines the spherical volume that is theoretically shielded by a lightning conductor based on the strength of the first arc's discharge current. The greater the stream, the greater the chance of being captured and the larger the protected area.

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c. Capture surface areas

When the protected site comprises multiple buildings or goes beyond the range of a single capture device (Lightning conductor), a protection strategy must be set up for the region, contrasting the various possible capture surface areas. When a site is made up of structures of various heights, it is always challenging to attain comprehensive coverage. By superimposing the protection plan over the area's layout, it is feasible to see sections that are not protected, but it must also aid in in-depth study.

- Lightning strike probability by calculating the primary strike points (towers, chimneys, antennae, lamp posts, masts, etc.)
- The sensitive nature of the buildings' equipment (Communication and computer equipment, PLCs, etc.)
- The businesses or the types of materials store's potential risk (fire, explosion, etc.)

It's also worth remembering that the numerous connections between buildings (computer networks, remote monitoring, communications, alarms, and power) might cause interference as a result of the electromagnetic field created by lightning or the voltage gradient created in the ground.

These connections can be safeguarded in two ways:

Shielding or the usage of Faraday cages, which will guard against these fields while also maintaining the link's equipotentiality (adjacent earthing conductor, twisting, conductor screen, etc.)

Galvanic decoupling, which electrically separates buildings (optocouplers, fiber optics, isolation transformers, etc.).

d. Down conductors

These serve as a connection between the lightning conductor (rod, cage, or wire) and the earthing electrode. They are exposed to high currents and must have a sufficient cross-section (minimum 50 mm2 copper), be flat (HF current), be firmly fastened, and take the shortest route possible. There must be no abrupt angles or elevations.Lightning strike counters can be installed on the conductors. The lightning conductor down conductor(s) should be connected to the bonding systems on each floor in structures with several stories. The voltage difference between the down conductors and the internal exposed conductive portions could create a spark over through the building's walls if this is not done.

Due to the increase in its high-frequency impedance, the circulation of the HF lightning current may produce a substantial voltage surge in the down conductor (several hundred kV). The effects of lightning current circulation in down conductors can be minimized in the installation by: – Increasing the number of down conductors to divide the current and limit the impacts produced by lightning current circulation.

Ensuring that the building's down conductors are linked to the bonding systems on all floors.

Developing equipotential bonding systems that include all conductive elements, including inaccessible ones, such as fluid pipes, protection circuits, concrete reinforcements, metal frames, and so on.Keep conductors away from sensitive places and equipment (computing, telecommunications, etc.).

e. Earthing system

This is a critical component of lightning protection: all exposed conductive parts, which are interconnected, must be connected, and the system must be capable of discharging the lightning current without causing a voltage spike in the earthing system or the surrounding ground. In terms of the discharge of the high-frequency lightning current, the low-frequency resistance value of the earthing electrode is less essential than its form and size, even though it must be low enough (10 O).Each down conductor must, in general, terminate in an earthing electrode, which can be made up of conductors (at least three) buried at least 0.5 m deep in a crow's foot arrangement or earth rods, preferably in a triangle configuration. When possible, increasing the number of down conductors and connection points (each level) and hence the overall scale of the equipotential bonding system is always recommended.At the same time, the earthing system must be capable of discharging the lightning currents in order to keep the bonding system's voltage rise as low as possible.

When the equipment to be protected is particularly sensitive (electronics with 0 V referenced to the bonding network, telecommunications, computing shielding, etc.), when an effective high-frequency earthing electrode cannot be established (for example, rocky ground), or when the scale of the installation is such that there are numerous voltage feedback points, additional measures must be taken to provide protection against a high-frequency voltage rise in the b.

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B. Internal protection

a. Active and passive protection of the installation

Fuse and circuit breakers, which are the most often employed safety devices, are too sluggish in comparison to the phenomena of lightning and cannot safeguard electrical or electronic equipment from overvoltage induced by lightning. This necessitates the use of voltage surge protectors. Active surge protection is provided by voltage surge protectors. However, they are only truly effective when carefully and precisely installed: model selection, positioning, connection, and so on. Other physical parameters of the installation (size, equipotentiality, earthing system, circuit isolation, etc.) are other determining variables in addition to this initial need. The term “passive protection” is used to put them all together. Surge protectors for voltage are also used to protect equipment.

Overvoltage threats from operations may occur statistically more frequently than lightning-caused overvoltage. Despite their reduced energy level, this overvoltage can harm a huge amount of equipment.Against electromagnetic interference up to several hundred kilohertz in frequency, such as interference induced by inductive or capacitive loads starting often, or even the operational modes of some devices (repetitive starting of welding stations, high-pressure washers, contactors, radiators, air conditioning units, heaters, etc.).

Despite their modest energy level, these types of overvoltage can hasten the aging of very sensitive equipment (computers, modems, TVs, HiFi systems, etc.). The goal of voltage surge protectors, on the other hand, is not to:
Filters must be employed to protect equipment from high-frequency interference.
Protect and install from momentary overvoltage caused by high or low voltage supply defects, such as neutral breaks.

b. Lightning strike withstand equipment

Regardless of how the lightning strike’s energy enters the installation, it creates overvoltage and current levels that are dependent on the installation’s construction and where the energy is created. The requirement to safeguard equipment from overvoltage must be based on a comparison between the potential value of a lightning strike based on installation conditions and the equipment’s impulse voltage withstands value (overvoltage category).

V.CONCLUSION

Although lightning is an important and necessary aspect of the earth’s ecology, it can also be devastating. It’s sometimes difficult to comprehend why some areas appear to be prone to lightning. Because they represent the shortest path from a cloud to Earth, very tall objects are frequently targeted. Lightning’s inability to find a rapid and easy path generally results in injury, destruction, and flames. A good lightning protection system can assist in providing that path, lowering the risk of damage to people or animals.

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