Daffodil International University
Dhaka, Bangladesh

Thesis Report
On
An overview of Lightning Protection System and its calculation.

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This thesis has been submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering.

APPROVAL LETTER

This thesis report titled **"An overview of Lightning Protection System and its calculation",** submitted by Md.Ridoy Ahmed ID: 163-33-326, Al-AminID: 163-33-352to the Department of Electrical & Electronic Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering and approved as to its style and contents. The presentation has been held on December 06, 2019.

Board of Examiners:

Declaration:

The thesis titled "**An overview of Lightning Protection System and its calculation"** has been submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering.

We hereby declare that this thesis has been conducted based on the geological aspect of Bangladesh and the data that has been mentioned and included in this thesis has been declared and all sources has been accurately reported & referred.

We hereby also declare that this document in its entirely or partially hasn't been submitted in the daffodil international university or at any university in order to obtain academic qualifications.

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ABSTRACT:

A rainstorm is fundamentally a tempest, described by lightning and thunder, lightning is a normally happening electrostatic release during which two electrically charged locales in the air or ground incidentally even out themselves, causing the quick arrival of as much as one gigajoule of vitality. At the point when the temperature rises, hot sodden air rises upwards-known as updrafts. Simultaneously, the cool air sinks downwards, and this is called downdrafts. The crash between the updrafts and downdrafts makes cumulonimbus mists and it produces lightning and thunder. Tempests happen wherever on the world's surface, one of the most hazardous convective climate occasions. An expected more than 1600–2400 tempests happen at any minute and 50,000 every day, around the globe.1-4 The geographic area of Bangladesh is a shown zone of cataclysmic events like tempest, dry season, flood etc.5 Bangladesh is confronting a long haul environmental change (Over the most recent 25 years normal temperature of Bangladesh expanded by 1.5°C). All rainstorms produce lightning. Lightning damage is a worldwide general medical issue speaking to the main source of climate related demise after tornadoes, streak floods, and typhoons. The wounds cause high mortality and noteworthy long haul grimness. Around the world, mortality from lightning is evaluated at somewhere in the range of 0.2 and 1.7 passings/1,000,000 populace, influencing mostly the youthful and individuals who work outside. Consistently, more than 20,000 individuals are influenced by lightning and a few thousand capitulate to their wounds. Another report shows somewhere in the range of 2,000 individuals are slaughtered worldwide by lightning every year. In Bangladesh, just a couple of studies have been directed on lightning. These uncover that the quantity of lightning occurrences in the nation is very high. Another examination shows that in Bangladesh, the rate of lightning fatalities is 0.9 per 1,000,000 populace for every year, which is higher than in high-pay nations. A sum of 1,476 individuals has kicked the bucket from lightning in Bangladesh during 2010-2016. Preceding 1981, the nation saw lightning strikes all things considered nine days each May. Since that time, the nation has seen strikes a normal of 12 days each May. National rundowns of lightning-related passings and wounds are hard to get in many creating nations including Bangladesh.

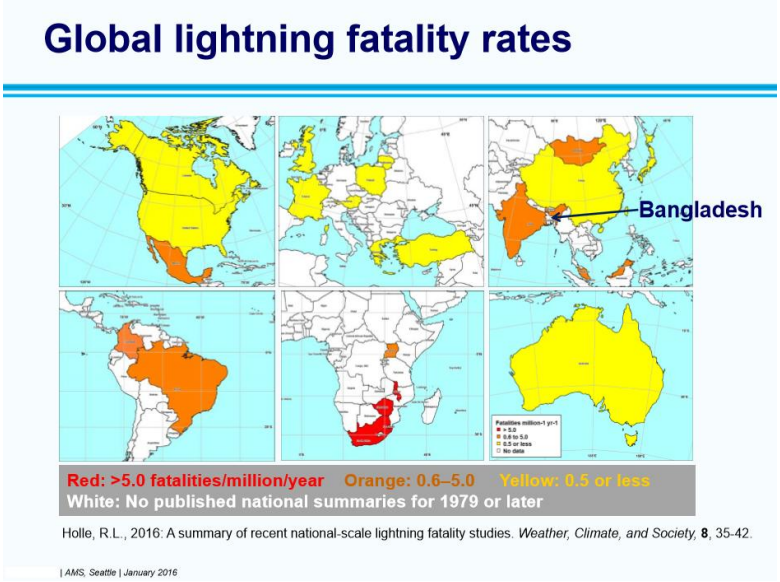

Figure no: 01 (Global lightning fatality rates)

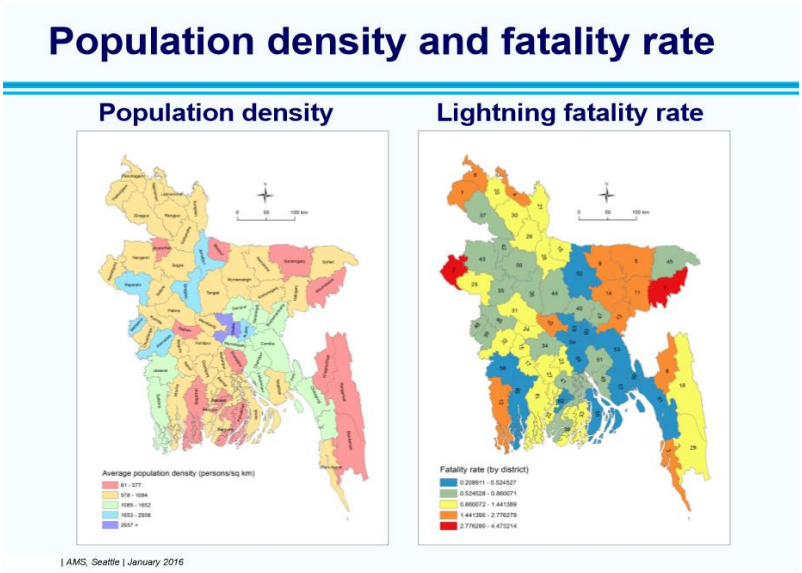

Figure no; 02 (Lightning fatality rates in BD)

Source: Holle, R.L., 2016: A summary of recent national-scale lightning fatality studies. Weather, Climate, and Society, 8, 35-42

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ABBREVIATIONS AND ACRONYMS

LPS - Lightning protection system

BNBC - Bangladesh National Building Code

NFPA. - National Fire prevention Association

AS 1768 - Australian Standard of the lightning protection system

RSM – Rolling sphere Method

Chapter 1

INTRODUCTION

1.1 How does lightning form?

Lightning is basically an immense electric flash that happens between the cloud and the ground. The charge and lightning create as a result of little impacts between ice particles inside the cloud. This happens a great many times each second and when this charge gets huge enough a lightning strike happen.

Lightning starts as static charges in a downpour cloud. Wind caught inside the cloud is extremely violent. Water beads in the lower district of a cloud get joined to the updrafts and lifted to higher locales where the amazingly chilly climate freezes them. Meanwhile, downdrafts in the cloud push ice particles beneath from the top. Where the ice going down gets the water meeting up, and afterward electrons are peeled off.

A solitary lightning blaze can be comprised of various strokes or beats of current. A lightning strike is basically a cloud to ground lightning stroke where it strikes the ground

Nations including Bangladesh..

1.2 Types of Lightning

• Intra-cloud lightning is the most well-known sort. It happens when lightning moves rapidly inside a cloud having inverse charges in various pieces of the cloud.

• When a positive accuse related of one cloud meets with the contrary extremity charge from another cloud, they make an electrical discharge known as Cloud to cloud lightning.

• Cloud to air lightning happens at the highest point of mists when the emphatically charged particles from the higher district thundercloud connect with contrarily charged particles around the cloud.

Since lightning has no particular way to arrive at the ground, it might decide to use any conductor accessible inside a structure, house or tree. This additionally incorporates any electrical gear like telephone, link, power lines, the water or gas pipes, or if there should be an occurrence of a steel-surrounded structure the entire structure itself. These are the most ordinarily utilized ways used by the lightning to arrive at the ground. Thus, lightning presents a few perils to our homes, business structures, and people.

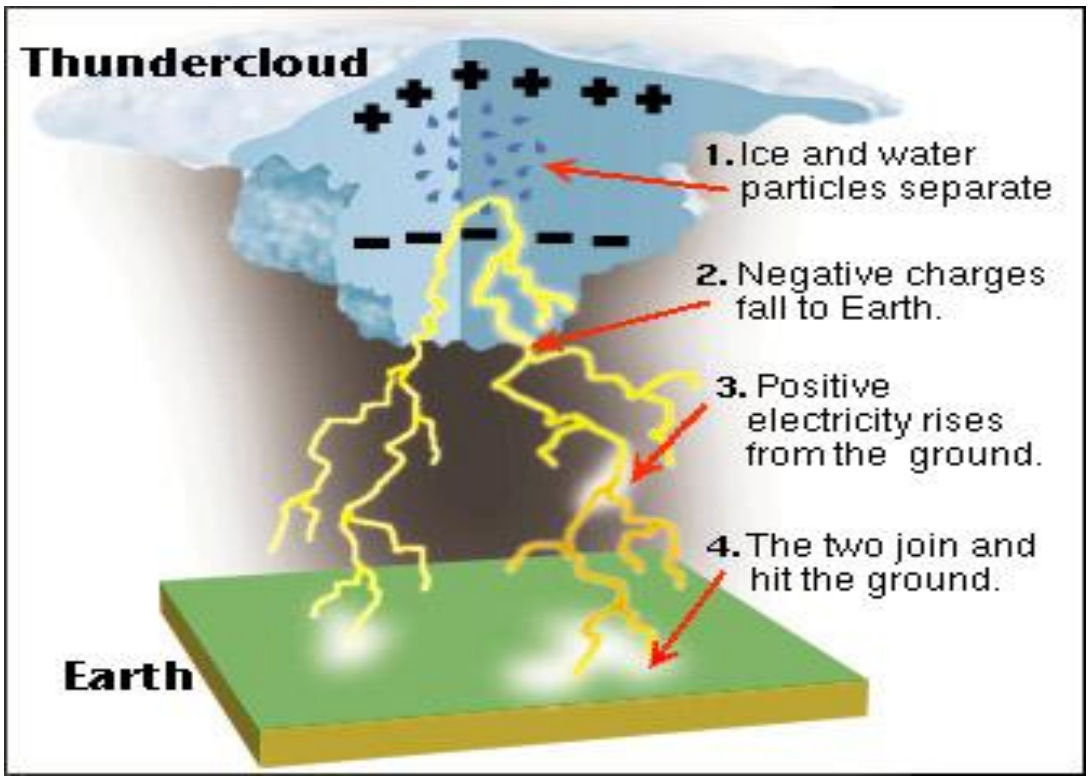

Figure no 03 - formation or the Lightning strike

1.3 Lightning Hazards

- **Fire** - When a lightning bolt having very large current comes in contacts with any conducting or flammable material (wood, steel, paper, gas pipes) in a building - including structural lumber or insulation inside walls and roofs, Fire can be started. When lightning goes through electrical wiring, it will often overheat or even vaporize them all, creating a fire hazard anywhere anytime along affected circuit.

District name	Area (km^2)	Population (million)	fatalities	Injuries	Rate of fatalities (per m per year)
Bagerhat	3959.1	1.5	53	13	1.26
Bandarban	4961.7	0.3	8	1	0.95
Barguna	1328.6	0.8	18	28	0.80
Barisal	2255.1	2.3	41	18	0.64
Bhola	2008.6	1.7	21	32	0.44
Bogra	2917.3	3.0	45	21	0.54
Brahmanbaria	1918.6	2.5	104	75	1.49
Chandpur	1697.4	2.2	33	17	0.54
Chapai Nawabganj	1727.0	1.4	140	110	3.57
Chittagong	4078.9	6.5	55	17	0.30
Chuadanga	1155.0	1.0	18	24	0.64
Comilla	3120.3	4.7	61	42	0.46
Cox's Bazar	2064.5	1.8	135	70	2.68
Dhaka	1523.0	8.8	51	19	0.21
Dinajpur	3460.8	2.6	59	55	0.81
Faridpur	2071.8	1.8	42	41	0.83
Feni	911.5	1.3	14	2	0.38
Gaibandha	2180.5	2.2	61	57	1.00
Gazipur	1679.3	2.4	44	20	0.65
Gopalganj	1548.3	1.1	30	22	0.97
Habiganj	2585.7	1.8	80	35	1.59
Jamalpur	1962.7	0.8	55	47	2.46
Jessore	984.0	2.1	31	19	0.53
Jhalokati	2070.2	2.4	4	1	0.06
Jhenaidah	2547.0	0.7	40	48	2.04
Joypurhat	716.5	1.6	15	20	0.33
Khagrachhari	2640.9	0.5	22	14	1.57
Khulna	3581.6	2.2	28	16	0.45

Table 1.2 (a): The fatality of the lightning strike in Bangladesh per district

Kishoregonj	2513.3	2.6	107	68	1.47
Kurigram	2264.5	1.8	62	26	1.23
Kushtia	1700.0	1.7	27	18	0.57
Lakshmipur	1201.3	1.5	23	18	0.55
Lalmonirhat	1227.1	1.1	71	61	2.30
Madaripur	1119.9	1.1	36	20	1.17
Magura	1047.8	0.8	32	39	1.43
Manikganj	1378.0	1.3	58	9	1.59
Meherpur	727.5	1.6	25	54	0.56
Moulvibazar	2712.9	0.6	70	70	4.17
Munshiganj	933.6	1.3	17	6	0.47
Mymensingh	4279.3	4.5	63	73	0.50
Naogaon	3450.9	2.4	42	73	0.63
Narail	966.7	0.7	25	11	1.28
Narayanganj	780.7	2.3	20	3	0.31
Narsingdi	1164.5	1.9	30	9	0.56
Natore	1919.5	1.5	35	33	0.83
Netrakona	2869.3	2.0	91	115	1.63
Nilphamari	1666.7	1.6	55	85	1.23
Noakhali	2635.4	2.6	33	19	0.45
Pabna	2418.5	2.2	55	19	0.89
Panchagarh	1393.4	0.8	47	25	2.09
Patuakhali	2463.2	1.4	35	46	0.89
Pirojpur	1112.7	1.1	34	6	0.10
Rajbari	1124.9	2.3	28	4	0.43
Rajshahi	2389.1	0.9	64	43	2.54
Rangamati	6058.5	0.5	18	12	1.29
Rangpur	2332.0	2.5	65	95	0.93
Satkhira	3457.3	1.1	75	70	2.42
Shariatpur	1282.3	1.8	6	1	0.12
Sherpur	1320.0	2.7	43	17	0.57
Sirajganj	2439.1	1.3	61	21	1.68
Sunamganj	**3706.8**	**2.1**	**132**	**128**	**2.24**
Sylhet	3414.7	2.7	45	25	0.60
Tangail	3455.7	3.3	56	82	0.61
Thakurgaon	1820.3	1.3	62	97	1.70
Bangladesh	**140 103.9**	**125.1**	**3056**	**2383**	**1.09**

Table 1.2 (b): The fatality of the lightning strike in Bangladesh per district

- **Sudden flashes** - Side flashes can move across various rooms in a building, possibly injuring anyone who comes in the way. They can also heat up different materials such as a fuel tank in a car or in a garage.

- **Damage to structures** - The explosive shock wave created by a lightning discharge can easily blow out the whole sections of the building walls, destroy concrete and plaster, and shatter everything made by glass into pieces.

Of course, installing a protection system in a building doesn't prevent a strike, but surely gives it a better, quicker and safer path to ground.

The framework segments like air terminals, links and ground conductor bars cooperate to divert the high-esteem flows from the structure, anticipating fire and hardware harm.

1.4 Common Lightning Detectors

A lightning finder is a gadget that identifies lightning created by rainstorms before it goes to the ground. It Includes various frameworks which are:

• Ground-based frameworks utilizing different radio wires.

• Mobile frameworks utilizing a heading and a sense of radio wire in a similar area.

• Space-based frameworks.

Ground and versatile frameworks use radio course discovering instruments, together with the assistance of explicit frequencies produced by lightning to discover the evaluated heading and force of lightning. Ground-based frameworks additionally use

a triangulation strategy from numerous areas to decide separation, while portable frameworks ascertain separation utilizing weakening and sign recurrence.Space-based detectors work from the satellites, and used to determine lightning range, place and intensity by direct observation of clouds.

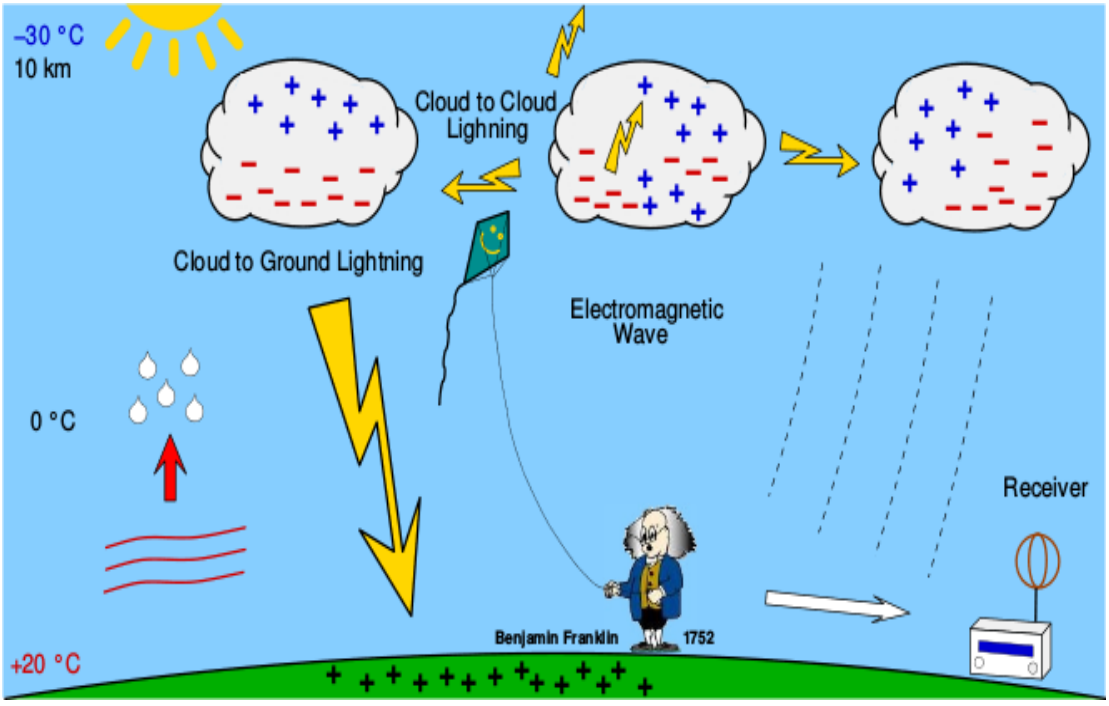

Figure no 04: Lightning strikes dynamics

Source: https://www.eldoradoweather.com/lightning.php

Chapter 2

2.1 The BNBC standards & continuous efforts of Bangladesh for implementing LPS.

Bangladesh National Building Code (BNBC) first proposed in 1993 and lawfully authoritative in 2006 gives clear guidelines for setting up "Lightning Arrestor" in structures more than 33m high. Fire Service and Civil Defense Department and Public Works Dept. (PWD) of Bangladesh's administration are working perseveringly in lightning mindfulness and security in like manner individuals. It is required to take the NOC (No Objection Certificate) Certificate) for all real estate agents which agree to the BNBC code. Outskirt Guards Bangladesh (BGB) finished an overview on lightning and flood security in September 2008 in the nation's uneven southeast bit flagging locales and camps. Barapukuria coal digging organization began for setting up a modernized lightning assurance gadget from 29th September 2008.

Establishment of a Lightning Protection System ought to in a perfect world be finished during development the same number of kinds of Lightning Protection frameworks can be hard to retrofit to existing structures and would require down conductors to be introduced vertically on the outer dividers each 20 meters. During development, basic channels inside the solid can be utilized to move lightning current to the ground, however there ought to be a persistent structure of funnels from rooftop to the ground. In the event that this coherence isn't kept up, at that point the utilization of committed down conductors is enormously useful.

Source:

- Bangladesh national Building Code (BNBC) part-8, chapter-2, figure 2.9.
- National Fire Prevention Association (NFPA-780)

2.2 Main Components of a Lightning Protection System

A Lightning Protection System consist of:

1. Air terminals (lightning rods or strike termination devices)
2. Bonding conductors.
3. Ground terminals (earthing rods, plates, or mesh)
4. Connectors.

Air terminals are placed directly along the upper points of a roofing structure and are electrically bonded together with down conductors or down leads. These are linked together by a single route to one or more grounding terminals. All the connections to the earth electrodes must have very low resistance as well as low self-inductance.

2.3 How does a Lightning Protection System work?

At the point when a structure or structure is struck by huge electrical jolt, LPS gives it an other conductive course through an air terminal and earth, so most of the lightning's flow goes to the way of the Lightning Protection System, with significantly less flow finishes the delicate hardware and combustible materials.

Extreme harm to a structure happens when high voltages move too rapidly and sidestep the resistance of security framework. As lightning can send very high voltages into an electrical establishment, curves can seize various spots, which can cause gigantic physical harm and even start in a structure.
Lightning can enter a structure from multiple points of view like:

a. Striking a metal item or a channel on the rooftop.

b. Striking a structure legitimately.

c. Striking a tree or generation office close to the structure.

d. Hitting an electrical cable or wire fence close to the structure.

2.4 How does a Lightning Protection System protect a building?

Lightning Protection Systems are utilized to limit or to a great extent keep lightning strikes from harming the delicate hardware and pulverizing the structures by fire. These frameworks particularly reduce the fire peril which lightning pauses dramatically to different structures in its range. In the event that lightning

travels through any composite, permeable structures or water-contained vessels or materials, at that point these materials have an immense hazard to detonate if their water content is transformed into steam by the enormous warmth delivered through lightning momentum. This is the reason we see various trees broke by lightning strikes all the time.

The AS1768 Standard supported the Lightning Safety Design dependent on the Rolling Sphere Method. This method requires to follow up in general structure for complete insurance. All parts of the structure that the circle contacts are viewed as presented to guide lightning strokes and would should be ensured by the situation of ground lightning poles and different air terminals.

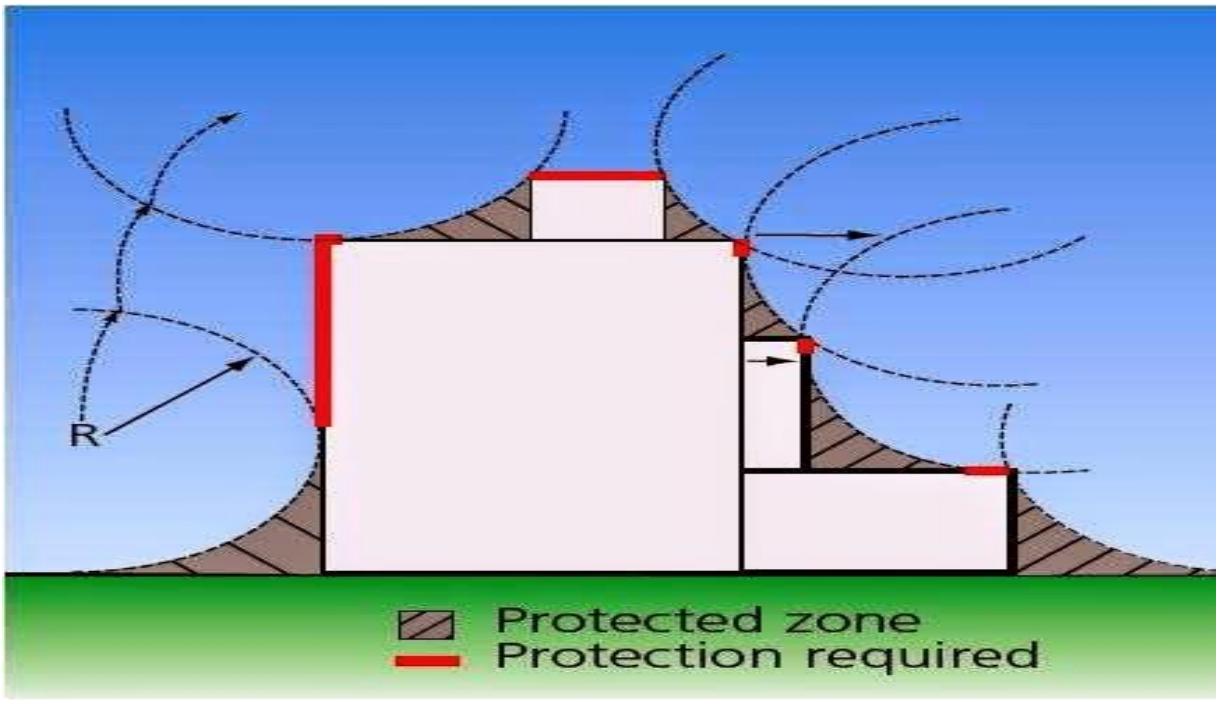

Figure 05: Rolling sphere Method

For the most part, all the air terminals should be set so that the moving circle just interacts with the upper surfaces. Extra air terminals must be introduced at the focuses, where the moving circle contacts the external segment of the structure to guarantee ideal wellbeing.

A few structures are at higher danger of being struck by lightning then the others. The evaluated hazard for a structure to be hit by a lightning jolt relies on its all out region, the tallness, volume, and the quantity of lightning strikes every year per mi^2 for that territory.

Source:

AS/NZS *1768*:2007. Australian/New Zealand Standard. ™. Lightning protection.

Chapter 3

3.1 Designing an LPS Using AS1768

The rules contained in AS1768 are prescriptive and allow designers to follow and implement the key guidelines to achieve maximum safety. These are summarized below:

i. Air Terminals (Clause 4.3.2 of AS1768)

(a) Always use air terminals to ensure the most helpless territories like focuses and corners; Use the moving circle strategy to confirm if the less defenseless parts like edges are sheltered and if not, include more terminals; Check if the least powerless segments like level surfaces are secured or not.

(b) The air terminals ought to be set legitimately on to the most undermined territories; If a flat strip conductor is utilized, it must be straightforwardly set on the necessary part; for a vertical pole, the ideal length will be at the very least 500mm, and it will likewise be mounted on the part it is to secure or inside 1m or 1/2m its length.

ii. Protection of Roofs (Clause 4.11.2 of AS1768)

Even conveyors, for example, link on parapets or an iron tie and metallic items, for example, flagpoles, metal railings, steel plants, and rooftop get to stepping stools ought to be utilized as air terminals to guarantee the wellbeing of a planar rooftop surface. These must be set at a tallness extending from 500mm to 600mm over the part to be secured, that way the conductors or items will be at a most sensible stature to accomplish the focused on capture productivity.

iii. Down Conductors (Clause 4.3.3 of AS1768)

(a) Main conductors shall interconnect all air terminals and shall form one or more paths to earth via down conductors, such that the spacing between the down conductors does not exceed 20m.

(b) A down conductor should be connected directly below an air terminal used to protect the most vulnerable parts; if the air terminal is on an exposed roof side or corner, its down conductor will also help becoming part of the air terminal to ensure the safety of a vertical edge below it, as it is necessary for big and high rise structures.

iv. Earth Terminations (Clause 4.3.4 of AS1768)

(a) The amount of earth resistance should be very low, and all the necessary measures must be taken to achieve 10 ohm or less resistance for the whole interconnected LPS earth termination body. All the equipment should be bonded together at the ground level for all conducting or metallic surfaces.

(b) It is desirable that there should be one earth terminal per down conductor.

During its formation lightning moves in any direction, but only until it finds a way to ground: then the path for its discharge is created. High rise buildings are the preferred points for lightning strikes, so for calculating the equivalent venerable area of any structure, a surface of 3 times its height and area is considered. Also, for buildings higher than 60 meters, lateral impacts should also be kept in mind.

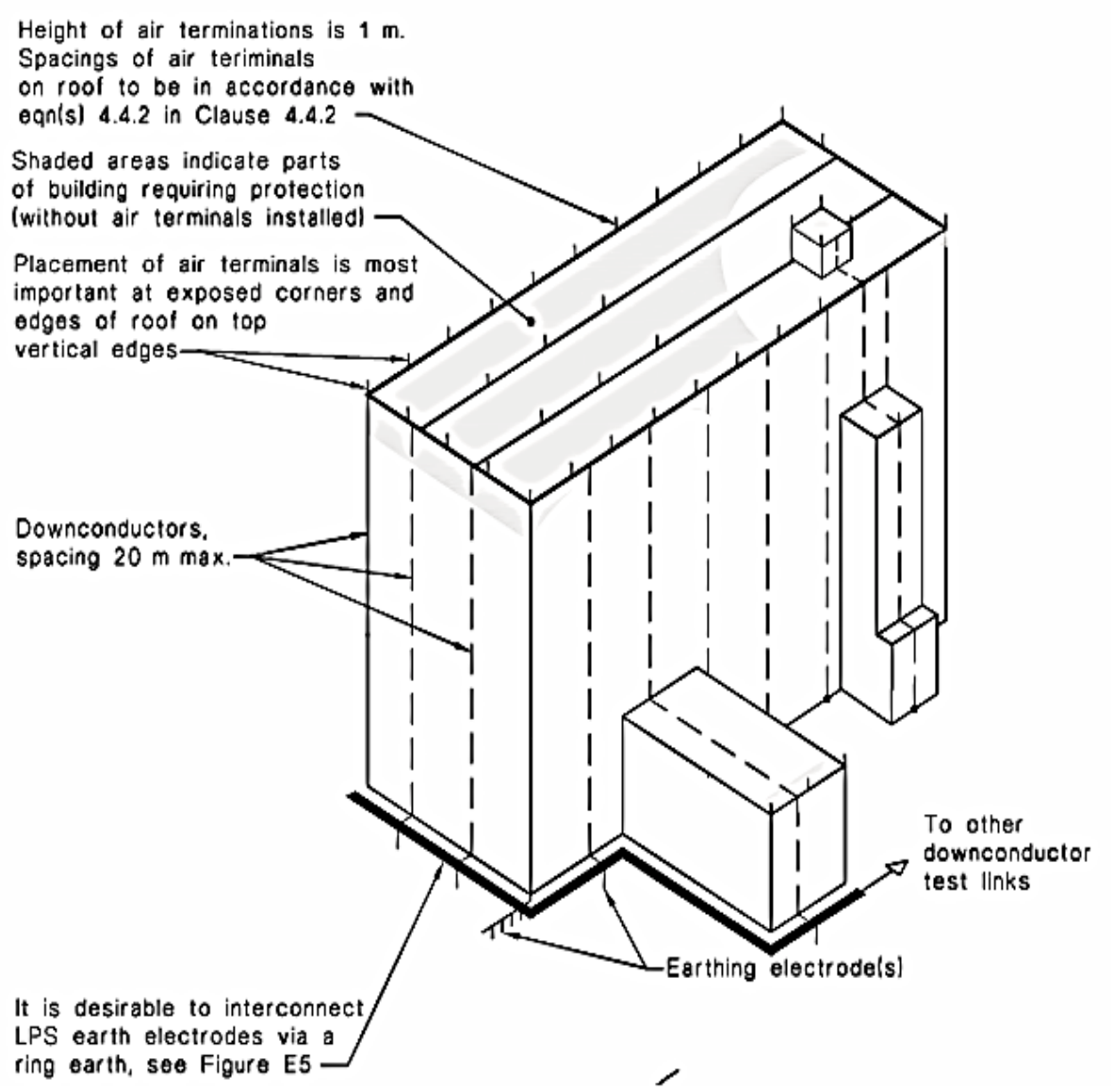

Figure 06: Design of LPS

Chapter 4

4.1 Maintenance Requirements for Lightning Protection Systems

Lightning Protection Systems are intricate systems. Just climate, however, extraordinary temperatures and fast breezes have an exceptionally negative impact on lighting security frameworks. Additionally fabricating overhauls including new development, building options, re-material or changing and adjustments to various electrical, mechanical or correspondence frameworks can influence a framework's presentation. Every building maintenance plan must incorporate yearly lighting security gear support.

With respect to security gauges, A Lightning Protection Test and Earth Grid Test must be done when the establishment has been finished. The establishment of a Lightning Protection System must be structured and introduced by a concerned proficient. All the security codes and gauges ought to be pursued. By law, affirmed testing must be performed inside a two-year time allotment.With routine maintenance, we will able to:

- Inspect lightning rods and other equipment before damage.
- Check for any loose connections.
- Monitor new roof installations and instruments.
- Assure that down-conductors have a nonstop path from ground electrode system to lightning rods
- Inspect lightning spike arrester devices.
- Summary report on system for compliance with latest codes.

4.2 Lightning protection for high rise buildings

The most recent development methods have permitted imaginative auxiliary improvement and advanced creation costs, so these days huge houses and high rises are especially ordinary in urban communities, even in those with a high lightning thickness. They are for the most part significant structures, situated in the fundamental business focuses and as a rule have delicate gear. The destructive outcomes of an uncontrolled lightning strike are additionally hazardous for human lives inside the structure, because of the troubles in clearing when lightning cause a fire.

Lightning assurance guidelines demonstrate that, other than the rooftop, for structures and structures higher than 60 meters the 25% upper part ought to be secured with an air end framework. For tall structures, every one of the pieces of the structure above 120m should likewise be furnished with insurance.

Tall structures are regularly made with metallic interconnected materials and structures that might be utilized as a piece of the lightning security framework, even as horizontal air terminals. It must be remembered that every one of the components on the rooftop ought to be secured and, on the off chance that the upper part is accessible to the overall population, a neighborhood storm finder ought to be introduced so as to maintain a strategic distance from individuals remaining on the rooftop in the event of abrupt peril of lightning strike.

An appropriately planned LPS shield and secure powerless structures, distinctive scope of gear, and trees by giving an unmistakable route to the ground, which innocuously

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